MEN OF MEDICINE

Also by Katherine B. Shippen

MEN, MICROSCOPES, AND LIVING THINGS

I KNOW A CITY

A BRIDLE FOR PEGASUS

LIGHTFOOT

THE BRIGHT DESIGN

THE GREAT HERITAGE

NEW FOUND WORLD

MEN OF MEDICINE

by Katherine B. Shippen

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"Honor the physician . . .
according to thy need of him
with the honors due him. . . .

"The skill of the physician
shall lift up his head;
and in the sight of great men
he shall be admired."

-Apocrypha, Ecclesiasticus 38:1, 3

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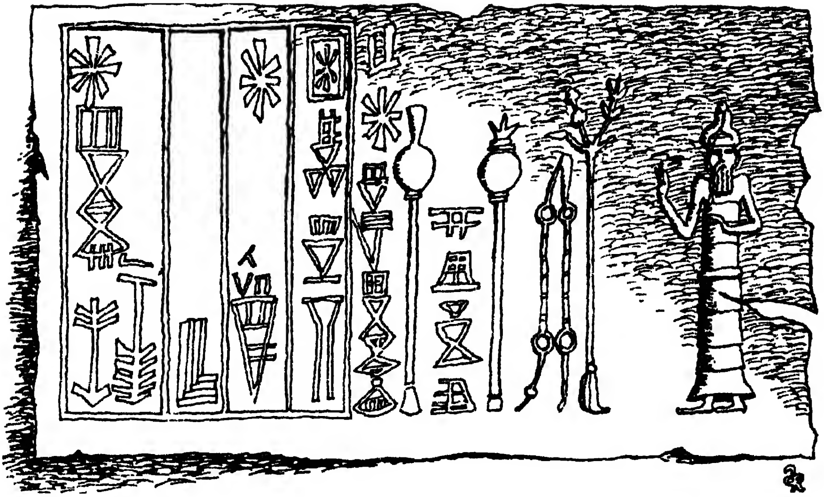
MEN OF MEDICINE



I. THE FIRST PHYSICIANS

MORE than five thousand years ago in Sumeria, the ancient country that lay in the Tigris-Euphrates Valley, a priest-physician entered the door of a house where a sick man lay. The doctor's name is not known: he was one of the many priest-physicians who went about their work in the valley.

Like all the men of his calling then, the physician wore a long fleece petticoat, and his beard was carefully curled. He had, moreover, such a very tall, pointed hat that he had to bend his head in order to enter the door.

As was customary, the family of the sick man had tried all sorts of home remedies before they sent for the physician. Only when these had proved of no avail was the patient's family convinced that the sickness had come because the

gods willed it. Since they had no way of communicating with the gods, they had sent for a physician from the temple.

The priest-physician brought with him no medicines and no instruments. Men had known something about bone-setting and skull surgery since the very earliest times, but sickness, the Sumerians believed, was not to be dealt with by means of surgery or specific medicines. The priest-physician would treat his patient by spells and incantations.

When he came to the sick man's bed, the physician went to work immediately. It was clear to him that the patient had probably neglected or insulted one of the gods. Therefore, he began to ask a great many questions so that he might make a kind of diagnosis.

"Have you broken any taboos?" he asked. "Have you failed to give sufficient meat and drink to your ancestors, and so offended them? Have you been faithful in wearing an amulet?

"Perhaps," the physician queried further, "you ate fish on a day it was forbidden? Did you observe that a dog was barking outside the city gates at sunset? Or did you notice a crow on a branch at the right-hand side of the road, as you walked home?"

With questions such as these the priest tried to find out how his patient had offended, why he was sick.

The physician knew, of course, that the sickness might have come, not through any fault or neglect on the patient's part, but through the acts of others, or through the curse or spell of some enemy, for the world was filled with perils. So he asked the patient more questions.

If the patient could not help by answering them in a satisfactory way, and the physician therefore did not know which spirit to exorcise, then he must name them all. The demon that caused the sickness would leave the patient if he heard his name spoken.

Both doctor and patient knew that the evil spirits that plagued men were of many kinds. Some were disembodied human souls that could find no rest and wandered up and down the face of the earth. They might fasten themselves on anyone with whom they had once come in contact.

Some, on the other hand, might be demons that hid in dark corners or in rocky caverns. They went slinking through the streets at night, and sometimes hid in people's bedchambers, where they hovered over the bed and threatened to pounce if a man closed his eyes. Those demons were sometimes only half human, without face, limbs, or ears—horrible even to think of.

There were seven of these demons that plagued men more than all the others, and the priest-physician did not neglect to recite this incantation for them.

> "Seven are they! Seven are they!
> In the ocean deep, seven are they!
> Battening in heaven, seven are they!
> Bred in the depths of ocean,
> Nor male nor female are they,
> But are as the roving wind blast.
> No wife have they, no son can they beget.
> Knowing neither mercy nor pity,
> They harken not to prayer or supplication.
> They are as horses reared among the hills."

But the demons that caused sickness were sometimes so dreadful that even the most clever priest could do nothing to help. Therefore he called on Ea, the ancient god of the city of Eridu, and the god of light and goodness.

"O Ea, King of the Deep, see,
I am the magician, I am the slave,
March thou on my right hand.
Assist [me] on my left.
Add thy pure spell to mine;
Vouchsafe to me pure words;
Make fortunate the utterance of my mouth;
Ordain that my decisions may be happy.
Let me be blest, where'er I tread.
Let the man whom I touch be blest."

When Ea's help had been secured, the priest turned to his patient with a soothing charm, saying:

"He that stillest all to rest, that pacifiest all,
By whose incantations everything is at peace,
He is the great Lord Ea,
By whose incantations everything is at peace.
When I draw nigh unto the sick man
All shall be assuaged. . . .
When I draw nigh unto the sick man
May Ea, King of the Deep, safeguard me."

While the priest recited these incantations, he offered honey, dates, butter, and garlic to bribe the evil spirit so that it would leave the sick man's body. The offerings were later burned.

The sick man's family crowded round his couch while all this was being done. When they saw that the patient was no

better, they did not abandon hope, for the priest had still other resources.

He made the patient swallow a nauseating concoction: if the mixture was sufficiently unpleasant, the evil spirit would go away. Then he made a fire and fanned the acrid smoke across the bed. This too might cause the demon to depart. When these measures also failed, he modeled a little doll of wax and tried to persuade the demon to enter it.

And now he began a new chant, rubbing the patient with butter as vigorously as he could, and saying:

> "Butter brought from a clean stall,
> Milk brought from a clean fold,
> Over the shining butter brought from a clean stall,
> Recite an incantation.
> May the man, the son of his god, be cleansed,
> May that man, like butter, be clean,
> Like that butter cleansed,
> Like refined silver shine,
> Like burnished copper glitter!"

When the patient had at last been cured by such ministrations as these, the priest-physician returned to his temple, and the patient to his customary ways, walking again through the ancient streets of the Sumerian city, where he ran the risk of being beset once more by the same dreadful unseen companions.

Sometimes, despite all the spells and incantations the priest-physicians could recite, they were unable to cope with the demons, and their patients died. Sometimes, in spite of all their efforts, they could not prevent the spread of disease.

Sometimes plague spread through the valley, killing high and low alike. Then the priest-physicians, having nowhere else to turn, looked to the sky, the abode of the gods.

In the temples, the priests had collected an immense number of records showing what the positions of the constellations had been when such catastrophes had occurred in earlier times. Was it not reasonable to suppose that when the constellations were in similar positions, like events would occur again—that the plague would grow worse if a certain group of stars was in one part of the sky; that it would abate if that group moved to another?

The liver of a sheep with its curious markings was another way of obtaining information. This organ, which the priests had often studied when sheep were sacrificed at the altar, had more blood than any other part of the body. It was the seat of life, they thought—a mysterious abode. They had made a clay chart of a typical liver, and any variation from this pattern in the liver they were examining served to inform them of coming evil or good fortune.

So a patient either in time of epidemic or of ordinary sickness might be told by the priests what his prognosis was, either by the stars or by examination of a sheep's liver.

There were times, of course, when all treatments and all omens failed. Then it was the custom to carry the sick man out into the street so that every passer-by could look at him and give advice, telling whether he had ever had a sickness of this kind. This might be called the most scientific approach to the practice of medicine that the Sumerians had.

So the centuries passed in the Valley that lay between the

rivers, and year after year the people, through their priests, called on the gods to help them in their suffering. Sometimes, as might be expected, the sick and injured grew well again; sometimes they died, believing they had offended the deities to whom they prayed.

With the passage of time the walls of the old Sumerian cities crumbled, and new cities were built on the ruins where they had stood. Babylonians succeeded Sumerians; Assyrians succeeded Babylonians. Kings and queens, surrounded by the bodies of their followers, lay quiet in their tombs. From time to time the Valley resounded with the clash of arms and the noise of bloody combat. Then the new rulers smashed the ancient temples and set up images of their own gods.

At Babylon the young Hammurabi erected his slab of black diorite on which were written the laws by which his kingdom should be governed. In this, the first written code of laws in history, regulations for medical practice were made. And later Nebuchadnezzar built his palace, with its hanging gardens, and people wondered at its green beauty and the sound of its fountains. Then the Babylonians in their turn were swept aside when the Assyrians came down from the north and built their own palaces.

While all these things were happening, the ancient incantations which the Sumerian priests had recited continued to be used, but the names of the new gods were inserted. And sometimes new practices and medicines were used to heal the sick. Gradually men here and there began to write down memoranda on the best way to cure toothache or what

to do for a fever. Many of these memoranda were recorded on tablets of sun-baked clay—but they were scattered throughout the Valley, inaccessible to most of the people.

Now Ashurbanipal, the last of the great kings of Assyria, came to rule in the Valley in the seventh century before Christ. He built his great palace at Nineveh with the winged bulls at its gate. And in the palace he caused a library to be built, so that all the tablets of sun-baked brick with the medicines and treatments they prescribed could be brought together in one place. His men went into every corner of the Valley in search of the tablets. After a time they had collected eight thousand of them, and the king had his name written on every one.

When the great collection was finally complete, Ashurbanipal had a tablet set up for all who might come after him to read. This was the inscription:

> The palace of Ashurbanipal, King of legions, King of multitudes, King of Assyria, to whom the god Nebo and the goddess Tasmetta have granted attentive ears and open eyes to discover the writings of the scribes of my kingdom, whom the kings, my predecessors, have employed. In my respect for Nebo, the god of intelligence, I have collected these tablets; I have had them copied, I have marked them with my name, and I have deposited them in my palace.

Some of the tablets in Ashurbanipal's library are older than the oldest existing city in the Tigris–Euphrates Valley. They record prayers and incantations to be recited for the sick, lists of herbs and chemicals to be used in treating them, ad-

vice on the best way of curing the "fever-sickness," headache, nausea, toothache, and other ailments.

Here then, in the Tigris–Euphrates Valley more than five thousand years ago, were the first beginnings of what has grown into the great profession of medicine; the first attempts to help those who were suffering from sickness; the first recording of methods and prescriptions; the first medical library. While not far off, in the Valley of the Nile, another people were trying in their own way to cure the sick and make the injured well.

II. A TOMBSTONE AND SOME PAPYRUS ROLLS

A SMALL but beautiful monument still stands among the graves of the Egyptian grandees at Saqqara, on the edge of the Nile. It is the monument of Sekhetenach, chief physician of the Pharaoh who ruled Egypt in the Fifth Dynasty.

The Pharaoh raised the little monument because his doc-

tor had "healed the king's nostrils." Therefore the king wished him "a long life in happiness."

An old record explains:

Then the chief physician spoke before Pharaoh: "May it please thy soul, beloved Ra, that there be given me a limestone slab like a door for this tomb in the West-land." Then the king commanded and they brought to him two stone slabs like a door, from the quarry Ro'an, and set them up in the court of his palace Charert-Sahura. The chief taskmaster made the temple masons inscribe them as for the king himself. The court visited them daily. His Majesty ordered the inscription to be done over with blue-stone.

There are some who claim that Sekhetenach was not the first doctor whose name is known, but that it was Imhotep, born "in the harvest season" about 3000 B.C. Imhotep was a very great man. People talked of him for thousands of years after his death, and gave him the title, "He who comes in peace." Later he was made a demi-god, and later still was worshiped as a god. Many temples were erected to honor Imhotep, but these have fallen into decay and "are as if they had never been."

Imhotep was Grand Vizier to the Pharaoh, and he is said to have built the first stone pyramid that replaced the more perishable buildings of wood, brick, and masonry. He was "chief judge," "overseer of the king's records," "bearer of the royal seal," "chief of all the works of the king," "supervisor of that which heaven brings, the earth creates, the Nile brings," "supervisor of everything in this entire land." Moreover, he was saluted with the royal salutation, "Life, prosperity, and health."

But though he was widely known as a healer, no record of his medical work exists. So probably Sekhetenach and not Imhotep should be called the first *doctor.*

Down through a thousand years after those first physicians worked, we have no trace of medical practice in Egypt. But in a tomb where the wife of a Pharaoh was buried about 2500 B.C., a medicine chest was found. It held six little jars, one made of alabaster and five of the green stone called serpentine. In the jars were the dried remains of some drugs, and with them was some yellow linen, several spoons, and a couple of dried roots. All these were carefully packed in a straw basket, ready to be used in case of illness or accident.

The little straw basket with its jars, the records of Sekhetenach who could "heal the King's nostrils," and of Imhotep, who had the title "He who comes in peace"—these were small shreds of evidence that the Egyptians practiced medicine. But how did they practice? For many ages this was not known.

Then, in the nineteenth century, scholars succeeded in deciphering a large number of papyrus rolls, and the mystery was solved.

The people who lived along the banks of the Nile had a strong sense of history. They considered it a religious responsibility to pass down the knowledge they had accumulated from one generation to another, writing it in hieroglyphic characters on papyrus rolls. A number of these rolls dealt with medical subjects. The Ebers Papyrus and the Edwin Smith Papyrus are two of these.

The Ebers Papyrus is named for George Ebers, the

German who found the roll in Thebes in 1873. When he succeeded in deciphering it, he brought to light information about Egyptian medicine that had lain hidden for perhaps thirty-five hundred years. Even thirty-five hundred years ago the information which the scribe set down was not new. It had been collected and handed down from one generation to another; some of it may have originated in the Pyramid Age and have been known to Imhotep himself.

The papyrus begins with very old incantations or spells to be used in applying a remedy to a man's arms or legs, or for loosening or binding a bandage, or for administering a drug.

After the incantations, the papyrus describes the anatomy of the human body, with a surprising knowledge of the action of the heart and the blood vessels.

> The beginning of the physician's secret: knowledge of the heart's movement, and knowledge of the heart. There are vessels from it to every limb. As to this, when any physician, any surgeon, or any exorcist applies the hands or his fingers to the head, to the back of the head, to the hands, to the place of the stomach, to the arms or to the feet, then he examines the heart, because all his limbs possess its vessels, that is: the heart speaks out of the vessels of every limb.

Two hundred and fifty different maladies are described in the Ebers Papyrus—maladies very much like those from which people suffer today. A list of not less than seven hundred drugs is given—animal, vegetable, and mineral. Some of these were unpleasant concoctions of swine's ears and teeth, lizards' blood, putrid meat and fat, and the brains of a

tortoise. Some were herbs and minerals that are still in use today.

Directions on how to mix these prescriptions were carefully set down. Ointments were mixed with fat; remedies to be given by mouth were mixed with water, wine, or beer. Sometimes the medicines were colored to make them appear more attractive; sometimes they were flavored or sweetened to make them taste better.

In the margins of the Ebers Papyrus, beside the various prescriptions, the ancient owner has written his comments. "This is a genuine remedy," he says enthusiastically in one place. And, in another place: "Good!" And again: "Excellent. I have often tried it."

The Ebers Papyrus deals largely with medical prescriptions, but the Edwin Smith Papyrus describes Egyptian surgical practices. Edwin Smith bought this old papyrus roll in Thebes in 1862. It was written some seventeen hundred years before Christ was born, but scholars think that, like the Ebers Papyrus, its original may have been written nearly three thousand years B.C. It describes wounds, fractures, ulcers, and tumors, and tells how they should be treated. Splints of wood padded with linen should be used for broken bones, it says, or the splints should be of linen alone, covered with plaster or gum. Swabs of linen or lint will control bleeding, it states, and the linen bandages may be procured from the embalmers. It also mentions surgical stitching for the first time, saying, "Thou shouldst draw together for him his gash with stitching."

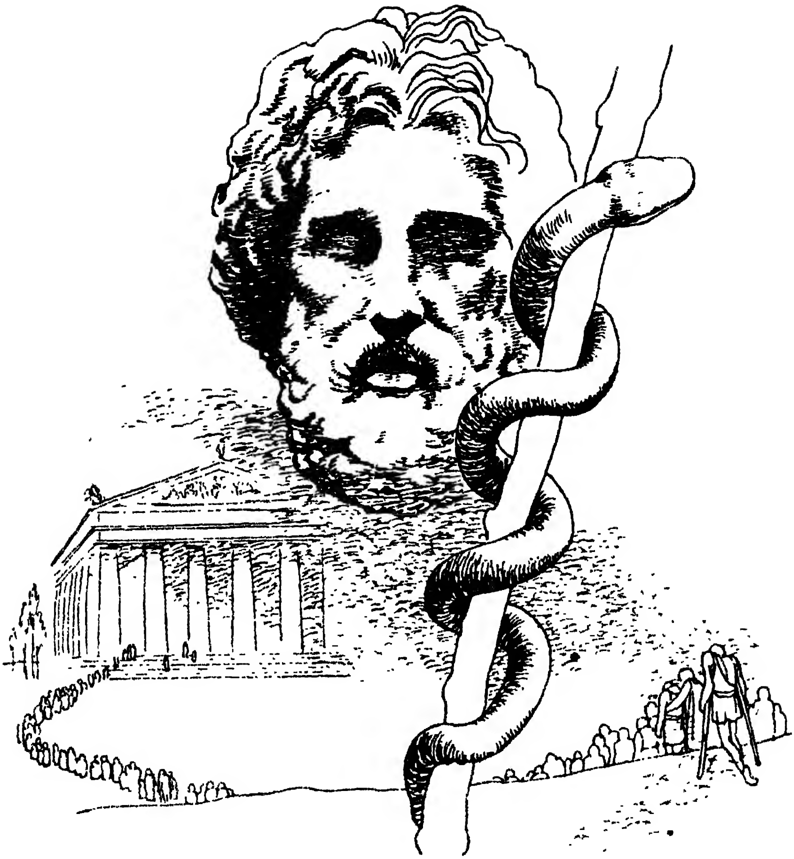
It is in the Edwin Smith Papyrus that the word "brain"

is first used. Most people up to that time thought that the seat of consciousness was either in the heart or in the abdomen.

There are a number of other old papyrus rolls that deal with medicine, and the ideas in them often seem modern. Throughout the centuries, the medical profession in Egypt grew in power and effectiveness. Perhaps the practice of mummification helped these first practitioners to become familiar with the anatomy of the human body.

As time passed, doctors in Egypt apparently began to specialize. Herodotus, the Greek historian who wrote in the fifth century before Christ, said that the Egyptian oculists were so well known in the ancient world that the Persian kings, Cyrus and Darius, both sent for them to have their eyes treated. He wrote:

> The art of medicine among them is distributed thus: each physician is a physician of one disease and no more; and the whole country is full of physicians, for some profess themselves of the eyes, others of the head, others of the teeth, others of the affections of the stomach, and others of the more obscure ailments.



III. "DUSTY FEET"

IN GREECE, where the blue sea washes up against rough coasts and rocky islands, where olive and vine bear fruit with little help from men, and sheep and goats find pasture on the rocky hillsides—there a different approach to the healing of the sick was made.

Although the Greeks admired physical perfection, they had to bear their share of pain and disease. But though they learned a great many things about the treatment of sickness from the Egyptians, and to a lesser extent from the people of the Tigris–Euphrates Valley, the Greeks worked out their methods of curing ills in their own way. They knew of two kinds of treatment. One was by incubation, or temple sleep; the other by careful study and observation, diagnosis and treatment. The followers of Asklepios, the first Greek physician, practiced temple sleep.

The Greeks have left a good many statues to show how Asklepios looked. They show the physician as a young man, handsome and perfectly formed; he was tall, with bare breast and a long robe, and in his hand he held a staff around which a snake coiled. Exactly how the idea originated that snakes were associated with healing has never been discovered. But snakes were represented in connection with the healing art in Babylon and Egypt and in Palestine, and they are still seen in the caduceus, the rod with its twining serpents, which is the symbol of the present-day medical profession. In Greece serpents were symbols of life, wisdom, and healing, and a number of them were always kept in the Asklepian temples.

It is not known who Asklepios was, or where he came from. Some think he was originally a human being, "a gentle physician," who was greatly beloved and remembered many centuries after his death. But some believe he was none other than a reincarnation of Imhotep, the Grand Vizier to the Egyptian Pharaoh, who had been worshiped as a god, for

ancient gods were appropriated, now by one people and now by another, with only a change in name.

If he was ever human, as he may have been, he became a god with the passing of time. Many ancient Greeks thought that Asklepios had always been a god, his mother the nymph Coronis of marvelous beauty, his father Apollo himself. Legend says that Coronis was faithless to Apollo and that he killed her. This would explain why Asklepios was brought up by the centaur Cheiron. Cheiron taught him so many secrets of healing and medicine that Asklepios was able to restore a dead man to life. Then Zeus killed him with a thunderbolt for his presumption.

Whoever he was, many turned to Asklepios and trusted him. After a time his worship became a great cult, so that many temples were built for him throughout Greece, and in other countries, particularly in Rome.

The temples of Asklepios were nearly always built high in the mountains and beside running streams or healing springs. Those who went to them spoke afterward of the beauty of the distant view and of the sound of running water continually in their ears.

Sick, crippled, wounded, blind—thousands of men and women made their way up the rough roads to the high temples in the belief that the god would help them. People who watched those sick ones pass called them the "Dusty Feet."

The richest and most beautiful of the Asklepian temples was near Epidaurus, the holy city on the east coast of Greece. The temple was not in the city itself, but about eight miles

beyond it, on a plain high in the mountains. The road that led up to it was flanked on either side by tombs. Along this road men and women made their way, some going slowly and resting often, some hobbling along with canes, some led, for they were blind. When at last they reached the temple precincts they entered through a gateway and, after walking up a long ramp, stood at last where theater, stadium, baths, gymnasia, and hospital were grouped around the three communicating courts of the temple itself.

The first court of the temple was called the Abaton. On its walls were graven the records of cures that had been accomplished there and which the newcomers were asked to stop and read. A long portico lined one side of the open court of the Abaton, and here, after the visitors had bathed and made their offerings to the god, they were invited to lie down and sleep. Sleep and dreams would release their spirits from their bodies, so that Asklepios would be able to talk with them.

It was not hard to sleep and dream in such a place. The sound of running water was soothing to the sick men's ears. The white-robed priests were peaceful as they moved quietly back and forth in the shadows, putting out one little oil lamp after another; the memory of the cures recorded on the walls was comforting and reassuring.

Sometimes the patients could not sleep because they were tired after their journey, or in pain. Then they must come back another night, and another, until sleep came.

Many letters remain that tell of the experience of temple sleep.

"A voice came to me at night, saying . . .," one writes. "A voice came to me in a dream," says another. And of one it was written, "He said he heard later a rushing noise coming from above his head and causing a pleasant sound." A mystical light appeared to one, and another said he saw the throne of Asklepios "blazing with fire."

Always Asklepios, the god, was kind and conciliatory, and always he was young, manly, and handsome. Sometimes he was surrounded by an odor "sweeter than autumnal myrtles"; sometimes he seemed to touch an injured part.

Asklepios was helped in his work by the snakes, of which the temple kept a good number. They glided quietly from one sleeper to another, licking their wounds or sores with their healing tongues. The patients received them gladly, being sure of their power to cure.

In the morning, when the sunlight came to the place where they had slept, the patients rose, and many of them were healed. Then they bathed, and made their offering at the altar of the god, and said a prayer of thanksgiving with hands upraised. "Be pleased," they prayed, "in your great condescension . . . to accept this prayer, which in sleep and vision you have inspired. Order it aright, I pray you, according to your loving kindness to men. Preserve me from sickness; and endue my body with such a measure of health as may suffice it for the obeying of the spirits that I may pass my days unhindered and in quietness."

Archaeologists have found many thank offerings among the broken fragments of the temple where they have lain covered with dust for centuries. One is a life-sized leg modeled in

terra cotta on whose surface varicose veins have been traced; another is a woman's breast; a third, a heart. These were sent to the temple near Epidaurus by patients who had slept there and been "cured." In one place, a beautiful marble slab was set up. It was carved in low relief and shows three representations of a boy with a swollen shoulder. In the first, he is entering the temple; in the second, he is lying asleep while the serpent, with arched neck, licks the painful joint; and in the third, he stands before Asklepios, who has leaned down to touch him.

More interesting than the votive offerings are the records of cures inscribed on the temple walls. Of these, forty-four may still be read.

One relates:

A man had his toe healed by a serpent. He was suffering dreadfully from a malignant sore on his toe, when the servants of the temple took him outside and set him on a seat. When sleep came upon him a snake issued from the Abaton and healed the toe with its tongue, and thereafter went back to the Abaton. When the patient awoke and saw that he was healed he said he had had a dream that a beautiful youth had put a drug on his toe.

Another, inscribed by a man who had been blind, left a record of how his sight had been restored.

Alketas of Halika. This blind man saw a vision. He thought that the god came up to him and opened his eyes with his fingers. The first things he saw were the trees of the temple. At daybreak he left the temple, restored in health.

And again, a man with paralyzed fingers had their use

restored to him, though at first he had scoffed at the very idea of cure by temple sleep.

A man whose fingers, with the exception of one, were paralyzed, came as a suppliant to the temple. While examining the temple tablets he expressed incredulity regarding the cures and scoffed at the inscriptions. In his sleep he saw the following vision. He thought he was playing at dice near the temple, and as he was going to cast the dice, the god suddenly appeared, seized his hand, and stretched out his fingers, one by one. When he had stretched them all out, the god asked him if he would still be incredulous as to the contents of the inscriptions on the tablets. He answered that he would not and the god said to him: "Since formerly you did not believe in the cures, though they were not incredible, for the future your name will be *The Unbeliever.*" When day dawned he left the sacred hall cured.

In the early days it was apparently possible for anyone who was sick or injured to seek out the temple, to sleep there, to dream and be cured. But as time passed, people seemed to find it more difficult to understand the dreams, and then the priests began to interpret them.

"The god wishes you to bathe in the sacred fountain three times a day, or to be massaged, or to do certain exercises, or to rest," the priests would explain. Gradually the interpretations of dreams brought directions from the god that were more and more severe. One man who was apparently suffering from nervous indigestion was ordered to rise at dawn, rub his body with mud, and run three times around the temple precincts. He did it, and went home rejoicing—and cured. Sometimes the god ordered relaxation—attendance at

a play in the nearby theater, or at the athletic contests in the stadium.

The treatment of some diseases by psychological means has been practiced since the Dusty Feet first came for help to Asklepios's temples. The powers of suggestion and persuasion are tried with more or less success even today. But the Greeks had a greater contribution to medicine than temple sleep. Hippocrates, the great physician of Cos, though he lived in the fourth century B.C., is still remembered as perhaps the greatest physician in history.

IV. THE GREAT MAN OF COS

THE rocky little island of Cos lies north of Rhodes off the coast of Asia Minor. If you walk up into the hills near the gulf there, you will come to an ancient plane tree whose widespread branches throw a pattern of light and shadow on the sandy ground.

"It was under that tree that Hippocrates taught his disciples," the villagers will tell you. "A great man, Hippocrates. . . . He lived here in Cos a long time ago."

But if you press them, you will find that they know very little about him, though there are many legends that attest to his greatness. "After his death a swarm of bees nested in his tomb," they say. "When the bees flew out from the tomb they had miraculous powers, so that their sting could cure all manner of ailments." Or again, they will talk of the terrible plague that afflicted Athens in the Periclean Age. "Hippocrates stamped out the plague by building fires," they say.

Not far from the plane tree a crumbling marble statue of a man in classic garments, and with a curling beard, stands on a newly erected stone platform.

"That statue was dug up in nineteen-twenty-nine," you will

be told. "It is the great Hippocrates. . . . You see, he was a very short man."

But, though he lived in the Golden Age of Greece, and much was written about his contemporaries, there is very little mention of Hippocrates, the man, himself. He probably lived most of his life in Cos, traveled widely at one period, and died at Larissa in Thessaly in about 377 B.C.

That is all that is known about Hippocrates—that, and the legend of his greatness, and the brilliance of his thought and of his work.

This brilliance comes to us, not directly, but with a kind of reflected light, for not a single book or even a single page written by Hippocrates remains for us to read. Yet we know his ideas as clearly as if he had put them down. For, during the years when he was teaching and practicing, his disciples made careful notes of what he said. These were collected and preserved, translated into many languages, quoted and discussed. The great body of these notes are known today as the Hippocratic Corpus. Whenever it is claimed, "Hippocrates said this," or, "Hippocrates said that," it is meant that these are the ideas set down in the Hippocratic Corpus. The ideas are new for their time, original and courageous, as if they had been spoken by the great man himself.

Like many of the Greeks of his time, Hippocrates must have looked scornfully at the Dusty Feet, making their way to the Aesklepian temple. He was a religious man, but he did not believe that sickness could be cured by sleeping in the temple or praying to the gods. Sickness is not sent by

the gods, or taken away by them, he said. Sickness has a physical basis. There is some material cause for every sickness. If we can find the cause, we can cure the disease.

A great announcement, this—a bold claim—as if the man had stood up fearlessly, protesting that he would trust his own reason in the face of all the gods. In one proud statement he set aside the spells and incantations, the superstitious offerings, the efforts to placate the hostile forces that plagued mankind.

If Hippocrates had lived in another age, his teachings might have been forgotten or ignored. But this was ancient Greece, and the search for truth was under way. Greek geographers, who had long believed that the earth was round, were trying to compute its circumference and wondering whether there were inhabitants on the other side of the globe. Greek astronomers had announced their belief that the sun was many times as large as the earth, that the earth rotates on its axis, and that it revolves around the sun. One Greek scientist, Eratosthenes, had stated that mind, not the gods, ruled the universe.

So it was not surprising that when a Greek physician advanced new theories of disease, his fellows listened with attentive ears.

"If there is a material cause for disease," they must have asked him, "what is it? What is sickness, and what is health?"

Hippocrates gave the answer that had been taught long before by Pythagoras. It has been called the doctrine of the four humors. He is quoted as having said:

"The body of man has in itself blood, phlegm, yellow bile, and

black bile. . . . Now, he enjoys the most perfect health when these elements are duly proportioned to one another in respect of compounding power and bulk and when they are perfectly mingled. Pain is felt when one of these elements is in defect or excess, or is isolated in the body without being compounded with all the others."

In cases where the sickness occurred because one of the elements was in excess, Hippocrates stated that it would be possible to relieve it by purging, the use of emetics, or bleeding, thus ridding the body of excesses and bringing the four humors into balance again. The practice of bleeding continued throughout many centuries, and the physician accompanied by his helper with a bleeding bowl was a common sight wherever medicine was practiced down through the Middle Ages and into modern times. George Washington died at Mount Vernon because of too many bleedings administered to relieve a common cold.

But while sickness might be brought on by a disproportionate mixture of the four humors, Hippocrates thought it might also be caused in another way. For there are four elements, he stated: earth, air, fire, and water. For each one of these there is a corresponding quality: dryness, cold, heat, and dampness. Excessive heat or cold, excessive dampness or dryness, may bring about sickness also.

But when you have found out the cause of the disease, be it the imbalance of the humors, or other conditions, how shall it be cured except by purging, emetics, and bleeding?

"Nature is the healer of disease," Hippocrates said. "Nature itself finds means and ways. The task of the physi-

cian is to help nature in any way he can, not to try to do too much himself, but to make it possible for nature to effect her cure."

And how shall this be done?

Like doctors of a later day, Hippocrates, according to the report of his students, believed that it was impossible for him to aid nature in healing sickness unless he had some understanding of the complicated structure of the human body. But here he was in difficulty. The Greeks regarded the human body with great reverence. It was unthinkable that anyone should dissect it. But how could anyone describe what lay beneath a man's skin if he had not seen it? The animals slain at sacrificial altars, the open wounds of soldiers on the battlefield—these could give only a hint of the structure and organization of the human body. It is not surprising, therefore, that though Hippocrates attempted to write about the organs, muscles, and skeletal structure, his work was sketchy and full of errors. He didn't have the least idea of the circulation of the blood, and didn't realize, as had the Egyptians, that the pulse had anything to do with the heart

He did know, however, that conception was the result of the union of male and female seed in the uterus; and, like the Egyptians, he believed that the brain was the seat of consciousness.

He is quoted as saying:

"From the brain only arise our pleasures, joys, laughter, and jests, as well as our sorrow, pains, griefs, and tears. . . . I hold that the brain is the most powerful organ in the human body. . . . Eyes, ears, tongue, hands, and feet act in accordance with

the discernment of the brain. . . . To consciousness the brain is the messenger."

If he could not get a very clear idea of physiology, since dissection was impossible for him, he could nevertheless get a very good understanding of disease by observing the symptoms of his patients and writing them down. His students reported that he made more than a thousand case histories in this way, recording the symptoms of every case that came to him, the treatment given, and the result.

He made no effort to cover up his failures.

"I have written this down deliberately," he is quoted as saying at the end of the case history of a patient who had died, "believing it is valuable to learn of unsuccessful experiments and to know the causes of their failures."

Hippocrates was interested in surgery as well as in medicine. The Hippocratic Corpus gives directions for cases of fractures and dislocations, of lesions of the spinal cord, club foot, or injury to the skull.

The Corpus directs:

> Let those who look after the patient present the part for operation as you want it, and hold fast the rest of the body so as to be all steady, keeping silence and obeying their superior.

In another place it discusses the kind and placing of lights, the position of the operator when an operation is performed, the instruments, and the drugs that will produce anesthesia.

> The nails [of the operator] neither to exceed nor come short of the fingertips. Practice using the fingertips. Practice using the

finger ends. Practice all the operations with each hand and with both together, your object to attain ability, grace, speed, painlessness, elegance, and readiness.

These things Hippocrates taught under his plane tree at Cos; but greater than any of his other teachings—wise, careful, and original though they were—were his teachings with regard to the relations that ought to exist between the physician and his patient. For these have set the standards by which physicians have practiced ever since.

I urge you not to be too unkind, but to consider carefully your patient's superabundance or means. Sometimes give your services for nothing, calling to mind a previous benefaction or present satisfaction. And if there be an opportunity of serving one who is a stranger in financial straits, give full assistance to all such. For where there is love of man there is also love of the healing art.

For some patients, though conscious that their condition is perilous, recover their health simply through their contentment with the goodness of the physician. And it is well to superintend the sick to make them well, to care for the healthy to keep them well, but also to care for one's self, so as to observe what is seemly.

It is said that when his disciples at Cos had finished their course of training they were required to take an oath before they began to practice. In most medical schools today the same oath, adapted to modern times, is required. It is called the Hippocratic Oath.

"I swear that I will look upon him who shall have taught me this art even as one of my parents. . . .

"I will follow that method of treatment which, according

to my ability and judgment, I consider for the benefit of my patients, and abstain from whatever is deleterious and mischievous. I will give no deadly medicine to anyone if asked, nor suggest any such counsel; . . .

"With purity and with holiness I will pass my life and practice my art. . . . Into whatever houses I enter I will go into them for the benefit of the sick and will abstain from every voluntary act of mischief and corruption; . . .

"Whatever, in connection with my professional practice, or not in connection with it, I may see or hear in the lives of men which ought not to be spoken abroad, I will not divulge, counting such things to be as sacred secrets."

V. GALEN, GLADIATORS, AND EMPERORS

"I BESEECH you have nothing to do with physicians," wrote Cato the Elder, the Roman patriot, several centuries before the birth of Christ. He took care of his own family and slaves by rubbing a green cabbage leaf on any painful or wounded part, or by having the ailing ones eat cabbage, either raw or cooked, and wash it down with a draught of wine. His friends pointed out that he lived to be more than eighty-five years old under this treatment, and

many of them followed his example. Physicians were not needed where plenty of cabbage was planted, they said.

Most people in Rome felt as Cato did. The Roman atmosphere was very inhospitable to doctors. There were some Greek slaves who acted as physicians, but Cato, and those around him, called them "poisoners."

Still, there were some herb doctors, for no people has been able to get along without some kind of medical practitioners. They went through the country, treating the people with decoctions of their herbs and with their incantations and amulets. And nearly all the country people believed in such gods and goddesses as Carna, the protector of the intestines; Febus, the goddess of fever; and Lucina, the goddess of childbirth. They were great believers, too, in the Greek Asklepios, whom they called Aesculapius, and for whom they built temples like the Greek ones.

Though the intelligent Romans thought very little of the practice of medicine, they set great store by the preservation and safeguarding of public health. Their enormous public baths were crowded with patrons. The baths of Caracalla could accommodate sixteen hundred people at one time, and the baths of Diocletian had room for three thousand. Here there were steam rooms, and rooms for massaging, pools of tepid water and cool water, and hot baths and cold baths. Great baths like these were built and patronized everywhere throughout the Roman Empire.

The Roman sewer systems were even more ambitious than were the baths. The Cloaca Maxima, the biggest of the Roman sewers, which was built in the sixth century B.C., was

so tremendous that it was said a load of hay could be driven through it. And that sewer was copied in many other places throughout the Roman Empire. There was running water even in the smaller towns. Archaeologists, digging up the ruins of those towns, were astonished to find water closets with running water (water closets were not known in Europe until at least a thousand years after Roman times).

But public health and sanitation are not medicine. There were no doctors of any note in Rome until Galen started to practice in Pergamum in Asia Minor. This was in the second century A.D. He was soon so eminent that he was talked of everywhere, and he was quoted as the great authority for generations after his death. No one thought it worth while to try to make any new investigations—Galen had known all there was to know about medicine, they said.

Galen's father, Nikon, had intended him to be a philosopher, not a doctor. But one night Nikon was instructed in a dream to educate his son as a physician. Since he believed implicitly in dreams, the boy was sent to study medicine.

"My father was calm, friendly, and honorable," Galen wrote—he had a way of inserting bits of his personal history in his medical writings. He did not speak so well of his mother, saying that she was bad-tempered, and that she "often bit her servants."

To study medicine in those days it was necessary to travel. So, after Galen had learned all he could in Pergamum, he went to Smyrna to attend the lectures of a physician named Pelops; and from there he journeyed on through Greece, Cilicia, Phoenicia, Palestine, Crete, and Cyprus. In all these

places he sought out the best-known doctors from whom to learn. Going in little boats or on donkey back was very slow, but this rather tedious method was the common way of traveling in order to get a professional education.

He came at last to Alexandria, that great city at the Nile's mouth, with its huge library and museum. Dissections had been done in the medical school at Alexandria in earlier days, and though these were forbidden before Galen's time, there were still complete human skeletons there that he could study.

He stayed in Alexandria for about five years, but thought little of the teaching in the medical school.

"The art of medicine was taught by ignoramuses," he said, "in . . . long, illogical lectures to crowds of fourteen-year-old boys who never got near the sick."

He resolved then that he would do better than theorize; he would really practice. So he went back to Pergamum. There luck was with him, for he managed to receive an appointment as official surgeon to the gladiators—an important appointment, carrying with it great prestige. He wanted to tend the men who had been badly wounded in the bloody combats of the amphitheater, because he wanted experience. He wanted to find out more about human bodies—about bodies that had been cut open, about broken bones and crushed skulls.

He did his work well. In the three years he served in the gladiatorial school it is said that not a single man died, though many were seriously hurt.

All the time he worked in Pergamum he studied, wrote,

and lectured, and he soon had a great reputation. But he was restless; he wanted to go to Rome, and this he finally accomplished.

Things were not so easy for him in Rome. In Pergamum everyone had known him; many had known his father before him. But in Rome he was a stranger, and no one paid any attention to him.

In an effort to make a place for himself he began to call on various established physicians who had come to Rome from Pergamum. One day he went to see an important physician named Eudamus.

It happened that Eudamus was ill. He was unable to move the third and fourth fingers of his right hand, and the most noted physicians in the city of Rome had been called in to treat him. All their efforts had been of no avail; it was feared that the paralysis would extend to the rest of the body.

Would they let him try to treat the patient? Galen asked. The doctors could think of nothing else to do, so they agreed to let him try.

Now, Galen had done some animal dissections when he was in Alexandria. Once he had dissected the spinal cord of an ape. He was wise enough, probably, not to mention that there might be any similarity between his rich patient and the ape, but he remembered the nerves connected with the spinal cord, and he began asking Eudamus some questions.

Yes, it was true that Eudamus had been thrown from a chariot some time before. He had struck his neck against a stone. The injury had not amounted to much.

So that was it, Galen must have said to himself. And he

treated the nerve in the neck, and not the finger. Before long Eudamus was able to move his finger again.

Galen's reputation soared. Rich men and women from everywhere came to consult him. The other physicians in Rome were jealous—but what did that matter to him? He was busy treating his patients, making speeches, writing. He said he wrote a hundred and twenty-five treatises on medical subjects.

Suddenly he left Rome—no one knows why. He went back to Pergamum, and when a messenger brought him an invitation to serve as physician to Marcus Aurelius, the emperor, he accepted. After Marcus Aurelius's death he was court physician to the Emperor Commodus, and after Commodus was murdered, to the Emperor Septimus Severus.

Perhaps the emperors were not such interesting patients as the gladiators had been. But all the while, Galen kept on lecturing, writing, studying, investigating—piling up a great sum of knowledge and errors, which were passed on to later generations.

He died, probably in the year 200 A.D., in the reign of the Emperor Septimus Severus.

Some people may wonder what in the end he accomplished, and why his influence was so great that people quoted him as an authority for fifteen hundred years after his death.

For one thing, he was a very great experimental physiologist. Although he followed the teachings of Hippocrates, he also made deductions of his own.

Although dissections of the human body were forbidden in

his day, he dissected apes and swine and from these made very clever inferences. Sometimes his deductions were wrong, but they were brilliantly made. "A physician needs to study anatomy, as an architect needs to follow a plan," he said.

He never understood the circulation of the blood, but he distinguished between the nerves that carry sense impressions to the brain and those that control movements. He also classified different variations of the pulse, distinguishing between slow, fast, and irregular beats, and trying to determine their relation to the patient's health.

Once he was called to treat a melancholy lady who persisted in the belief that she was very sick. While Galen sat near a window, examining her, Pylades, a handsome dancer, walked down the street, and he noticed that the lady's pulse beat faster. "There is a connection between the mind and the body," he maintained. "My patient's illness has its origin in her mind." The conception was a very modern one.

He made a great many other observations in surgery, physiology, and internal medicine, but, striking though they were, they might perhaps have been overlooked, had it not been for his own complete self-confidence. He was deeply religious, and he believed that every part of the human body was designed by the Creator for a special purpose.

But who can interpret the design of the Creator? people asked. How can we know what purpose the Creator had in mind?

"I can," said Galen simply. "I can demonstrate to you how

human nature acts with perfect wisdom. See how great is the work of the Creator."

He said this with such assurance that people everywhere believed him.

"Never yet have I gone astray," he wrote, "whether in treatment or in prognosis, as have so many other physicians of great reputation. If anyone wishes to gain fame . . . all that he needs is to accept what I have been able to establish."

In the years that followed, with the growth of the Christian Church, people were less and less interested in scientific truth. They looked more and more to authority. "There is only one physician: Galen," Marcus Aurelius said.

So it was Galen who was looked up to, not only at the time of the Roman Empire, but throughout the Middle Ages. What he said, be it right or wrong, sensible or not, was quoted everywhere. As time passed, scientific learning almost disappeared in Europe. But the Mohammedans kept scientific learning alive. They studied Galen's works and those of Hippocrates, and used them as a basis for their own discoveries.

VI. NESTORIUS TAKES SOME SCROLLS TO PERSIA

IT WAS Whitsuntide in the year 431 A.D. From every corner of the far-flung Roman Empire the fathers of the Christian Church were journeying toward Ephesus in Asia Minor. There after due and solemn deliberation, they were

to determine the official teachings of the Christian Church. Bishops and archbishops with their retinues traveled there in full panoply of jeweled vestments. Processions of the clergy marched toward the Church of Theotokos, chanting litanies and swinging censers. People hung from their windows to watch the splendor of the Holy Church passing along the street.

There was one who came like the others, in splendor and dignity, to take part in the deliberations. He was Nestorius, Patriarch of Constantinople. He brought sixteen bishops and an army with him, for he held views that were at odds with those of the other Church Fathers and wanted to be able to defend himself, both by argument and by force. He held that the Virgin Mary, though she was the Mother of Christ, was not to be worshiped: she was not the Mother of God, since God could not have a human mother. Such a view outraged the officials of the Church.

There were violent arguments. Words led to blows, and at length Nestorius's followers were stoned in the streets, and the Patriarch of Constantinople was excommunicated and banished to the Libyan desert.

Away from the uproar and din of Ephesus, Nestorius now made his way to Edessa in Asia Minor. There in due time he established a school and invited not only Christians but Syrians and Jews to teach in it. A library of parchment scrolls was soon collected at the school, among them copies of the Hippocratic Corpus. The school and its library were soon famous everywhere in the East.

But Nestorius's enemies were not content to leave him to

his teaching. They closed the school; the teachers were dispersed. Some of them fled as far as India, China, and Siberia.

Nestorius himself took refuge in Persia, and settled in the city of Jundi-Shapur. With him he carried a number of parchment scrolls; the ones with the Hippocratic teachings were among them.

Nestorius found peace and shelter in Jundi-Shapur, with its gardens and palm trees, its mosques and minarets. He found that the Moslems were greatly interested in his ancient scrolls. The dignitaries of Christian Europe had cared very little for the ancient medical writings that Nestorius prized so highly. To heal the body was not man's affair, they said; they left such matters to God, who was the Great Physician. Their concern lay not with the body but with the spirit.

The scholars at Jundi-Shapur, however, looked at things in quite a different way. Had not the Koran expressly stated, "O servant of God, use medicine, because God hath not created a pain without a remedy for it"?

So, throughout the great Mohammedan Empire that spread from Samarkand to Spain, Persians, Syrians, Jews, North Africans, and Spaniards were predisposed to an interest in medicine. And the scholars and savants at Jundi-Shapur looked at the scrolls Nestorius showed them with lively interest.

For nearly two hundred years, after that, the writings of Hippocrates that Nestorius had carried into Persia were the basis of discussion wherever Moslem scholars met. And gradually this knowledge, which at first had belonged to

scholars and students, was shared by all intelligent people. It became a popular pastime for them to ask one another medical questions and to try to guess the answers.

With all this interest in medical subjects, naturally the position of the physician became more and more esteemed, and Moslem physicians were richly rewarded for their services. One of them, named Gabriel, accumulated what amounted to more than fifteen million dollars from his practice. His regular salary from the caliph was fifteen thousand dollars a month, and he was given a present of five thousand dollars each year on New Year's Day. When he cured the caliph of an ailment, he became richer still, for he was given an additional hundred thousand dollars.

Just as the caliphs took pride in their doctors, they took great interest in medical manuscripts, and laid much emphasis on having them translated. The few manuscripts that Nestorius brought had been thoroughly studied, and a search was soon under way to find more medical scrolls to be deciphered.

In all the lands over which the Mohammedans held sway, Arabic was the language of the learned; and the lovely script in which the Koran had first been written was used by the scholars. At Jundi-Shapur, therefore, where many Europeans sought refuge, a translation school was set up, and caliphs and other rich men were soon vying with one another in buying rare old manuscripts to be translated into Arabic.

As time passed, the translators were moved from Jundi-Shapur to Bagdad, where the caliph had his palace. Then the secret of making paper was learned from the Chinese, and a

paper factory was built in Bagdad. After that, the library shelves held not parchment scrolls but books.

The greatest of all the translators was named Hunayn. His translations were valued so highly that their price was determined by their weight in gold. Ninety men worked under the supervision of this great scholar, and he took pains that their work should be as accurate as possible. Wherever feasible he obtained three manuscripts instead of one to work with, so that one might be checked against another. In this way he was assured that there was as little alteration in the original meaning as possible.

He took a great deal of trouble in finding manuscripts to be translated, and traveled long distances to seek them out. "I sought it earnestly," he wrote of one manuscript of Galen, "and traveled in search thereof in Mesopotamia, Palestine, Syria, and Egypt, until I reached Alexandria."

But Hunayn was more than merely a great translator. He was a man of character. Once the caliph called him and told him to mix a poison for one of his enemies. Great riches were promised to the physician when the deed was accomplished. Hunayn refused, however, saying that the doctor's task was to heal mankind, not to administer poison. Whereupon he was thrown into prison, where he stayed for a year.

Rhazes, another great Mohammedan physician, was more interested in original work than in translation. He was a Persian who had studied under Hunayn. He knew Greek, Persian, and Indian medicine, but he was interested also in philosophy, in space, time, motion, nutrition, meteorology, optics, and alchemy.

People came to consult Rhazes from all over western Asia. The difficulties he encountered may be judged from the subjects of some of his books:

> On the fact that even skillful physicians cannot heal all diseases;
>
> Why frightened patients easily forsake even the most skilled physician;
>
> Why people prefer quacks and charlatans to skilled physicians;
>
> Why ignorant physicians, laymen, and women have more success than learned men.

Rhazes wrote a number of treatises on separate diseases—a famous one on "Measles and Smallpox" which was translated into many languages was the standard book on these diseases until it was replaced in 1866.

It is said that this learned physician could not endure the sight of suffering and poverty. He earned vast sums of gold in his practice, but gave them all away, so that he himself was poor when he died.

He was seventy-three at the time of his death, and did not have time to finish his great "Comprehensive Book," which was to have been an assembling of all medical knowledge—Greek, Syrian, Indian, and Persian. It was a pity that he did not finish it, for it would have been the longest and most thorough work any medical man had ever attempted.

Meanwhile, at the beginning of the eleventh century, another great physician, Avicenna, began to teach and practice at Jundi-Shapur. In turban and long flowing robes, he

sat at the foot of a column in the Moslem temple, while his students grouped themselves on the steps below him. Avicenna was one of the greatest scholars of the Moslem world, and though it is believed now that he was a greater philosopher than physician, he has been called the "Prince of Physicians."

Avicenna wrote a book that was studied everywhere, and is still in use in the Orient. It is a gigantic encyclopedia that describes all the then known diseases in order, starting with the top of the head and working down to the soles of the feet. It contains also the whole pharmacopoeia known up to his time.

Some students believe that Avicenna was really Omar Khayyám, for he is known to have been a poet as well as a physician. One verse of the *Rubáiyát* in particular is attributed to him.

> Up from Earth's Centre through the Seventh Gate
> I rose, and on the Throne of Saturn sate;
> And many a Knot unravell'd by the Road;
> But not the Master-knot of Human Fate.

Rhazes and Avicenna lived about a century apart, and while they were working, the caliphs were building hospitals in many places. There were at least thirty of these in Persia, Morocco, northern Syria, and Spain. A very fine one was established by Haroun al-Raschid in Bagdad, but the greatest of them all was built in Cairo. Here men and women were cared for in separate wards; there were surgical wards as well as wards for eye diseases and fevers. The rooms for the fever patients were cooled by fountains, and all

day long and all through the night fifty voices recited the words of the Koran without ceasing.

The hospitals were intended not only as places for treatment of the sick but as places where medicine could be studied. Medicinal plants were grown in their botanical gardens, and they had libraries with hundreds of volumes, and courtyards where eminent physicians lectured on medicine. At night there was music to send the patients off to sleep, and at almost any hour there were storytellers to amuse any who wanted to listen. Each patient, on leaving the hospital, was given a sum of money, so that he might start his life afresh. This seems an improvement on our present system.

Building such hospitals as these was naturally an enormous labor, in which everyone participated. Laborers and passers-by, be they rich or poor, were waylaid and forced to help with the holy work. "Most people avoided going that way," one record states dryly.

When the Crusaders came riding into the lands of the "infidels," the Moslems were astonished at their crude practices. For the Europeans knew nothing of the work of such men as Rhazes and Avicenna, and had never heard of hospitals such as those at Cairo and Bagdad. Later the medical knowledge that the Crusaders brought back with them was to have great influence in Europe.

In 1258, Bagdad was sacked by the Mongols, and the great Mohammedan Empire, with all its beauty and learning, was destroyed. But by that time the medical school at Salerno in Italy had been established, and new medical discoveries were under way in Europe.

VII. THE SCHOOL AT SALERNO

FEW people in Europe in the early Middle Ages took much interest in the sick. Surely the Lord would care for His own, people said. Medicines and drugs were not to be depended upon for healing, anyway. More efficacious were the prayers and the repetition of Pater Nosters, pilgrimages to holy places, and votive offerings such as those that once had

been given Asklepios. In some places temple sleep was tried again.

Of course, everyone knew that certain saints would intercede to heal the afflictions of the human body. Saint Blaise might be called upon for ailments of the throat, Saint Bernardine for those of the lungs, Saint Appolonia for toothache, and Saint Lawrence for pains in the back. These were not all—Saint Erasmus had care of the abdomen; and three saints, Bridget, Trituana, and Lucia, of the eyes. In certain cases of insanity Saint Dymphna might be called upon, while Saint Avertin took care of people afflicted with epilepsy. And where all hope for the patient had been abandoned, a prayer to Saint Jude would often help.

To the mystical medieval mind it seemed only sensible to call on these holy people for assistance in illness; and the lighting of a candle before the saint's image appeared much wiser than calling a physician.

Nevertheless, in the ninth century, a medical school grew up on the shore of the beautiful Bay of Salerno, about thirty miles south of Naples. Legend has it that the school had four founders. They were Elinus, the Jew; Adale, the Arab; Salernus, the Latin; and Pontus, the Greek. Whether the legend of the four founders is true or not, it is certain that the school was liberal in accepting physicians of all kinds.

For many centuries Salerno had been a health resort. Patients, and with them physicians, flocked to the town from everywhere. Later it became a center both for trade and for learning as well as a medical center.

Many brilliant men held places on the faculty there. There

was one who dared to write a textbook disregarding mystical medicine and quoting Hippocrates, and another who ventured to say that the pulse and the urine should be studied rather than the stars. He recommended bloodletting and diet as treatment, rather than prayer.

Another doctor at Salerno practiced surgery and wrote a book about it. Still another prepared a cookery book with recipes for the sick.

Perhaps one of the most interesting of the Salerno doctors wrote advice for physicians on how they should deport themselves. Part of his book is called "The Doctor's Visit." It advises:

> When called to a patient, commend yourself to God. . . . On the way, learn as much as possible from the messenger, so that, if you discover nothing from the patient's pulse, you may still astonish him and gain his confidence by your knowledge of the case. On arrival ask the friends whether the patient has confessed, for if you bid him do so after the examination you will frighten him. Then sit down, take a drink, and praise the beauty of the country and of the house, if they deserve it, or extol the liberality of the family. Do not be in a hurry to give an opinion, for the friends will be more grateful for your judgment if they have to wait for it. If asked to dinner, do not hasten to take the first place unless it is offered to you. Send often to inquire for the patient, that he may see that you do not neglect him for the pleasures of the table, and on leaving, express your thanks for the attentions shown you.

Women as well as men practiced at Salerno. Four of these "Ladies of Salerno" were of special fame. Their names were Trotula, Abella, Rebecca, and Constanza. Trotula wrote a

textbook on obstetrics, but not much is known of the others, except that Constanza was held to be a great beauty.

In 1221, after the School at Salerno had carried on its work for over three hundred years, the German Emperor Frederick II of the House of Hohenstaufen incorporated Italy into his kingdom. He promptly ruled that no one in his kingdom should be allowed to practice medicine unless he had been passed upon by the masters of Salerno—"in order that the king's subjects should not incur danger through the inexperience of their physicians."

Then a strict set of requirements was drawn up. No one was to be allowed to study medicine unless he was twenty-one years old, could prove that he was of legitimate birth, and had studied logic for three years. The course was to last five years, with a further year of practice under the guidance of an experienced physician.

At the end of this time the candidate was required to pass an examination, and then to take an oath promising to uphold the teachings of the school, to administer no noxious drug, to teach nothing false, and not to keep an apothecary shop. Thereupon the candidate was given a ring, a laurel wreath, a book, and the kiss of peace. And only now was he permitted to call himself "doctor" and to practice medicine.

So it was at Salerno that physicians were first given degrees after a definite term of study. And at Salerno the term "Doctor of Medicine" first came into use.

The fame of the medical school spread fast. Gilles de Corbeil came to it from France and wrote two long poems in hexameter verse: one, "On the Urine"; the other, "On the

Pulse." It was the fashion in those days to write verses on all sorts of subjects.

Michael Scot, the great translator and astrologer, also came, and left behind him a prescription for an anesthetic.

> Take opium, mandragon, and henbane equal parts, pound and mix them with water when you want to saw or cut a man, dip a rag in this and put it in his nostrils. He will soon sleep so deep that you may do what you wish.

The mixture was forgotten after Michael Scot's time, as were many other things discovered at Salerno. It was many years before another anesthetic was found.

Meanwhile a long poem called the "Rule of Health of Salerno" had great popularity, was translated into many languages, and was read everywhere. No one knows who wrote it or whether it had more than one author. No one knows, either, whether the monarch to whom it was dedicated was the king of England or some other sovereign. One version of the poem begins:

> The Salerne School doth by these lines impart
> All health to England's King, and doth advise
> From care his head to keep, from wrath his heart.
> Drink not much wine, sup light, and soon arise.

From these general admonitions it goes on to give more specific advice. First, with regard to diet, it warns:

> The King who cannot rule his diet.
> Will hardly rule his realm in peace and quiet.

Then it proceeds to tell of various foods and their effects.

Cow's milk and sheep's do well, but yet an Ass's
Is best of all, and all the other passes.

The poem goes on to tell of other foods, of fruits and cheese, meat, fowl, and fish.

For healthy man may cheese be wholesome food
But for the weak and sickly 'tis not good.

It gives a long list of drugs and herbs that may be used as remedies for various diseases. For example:

Some affirm that they have found by trial
The pain of Gout is cured by Penny-royal.

The poem closes with a graceful blessing on the reader.

And here I cease to write but will not cease
To wish you live in health and die in peace.
And ye our Physick rules that friendly read
God grant that Physick you may never need.

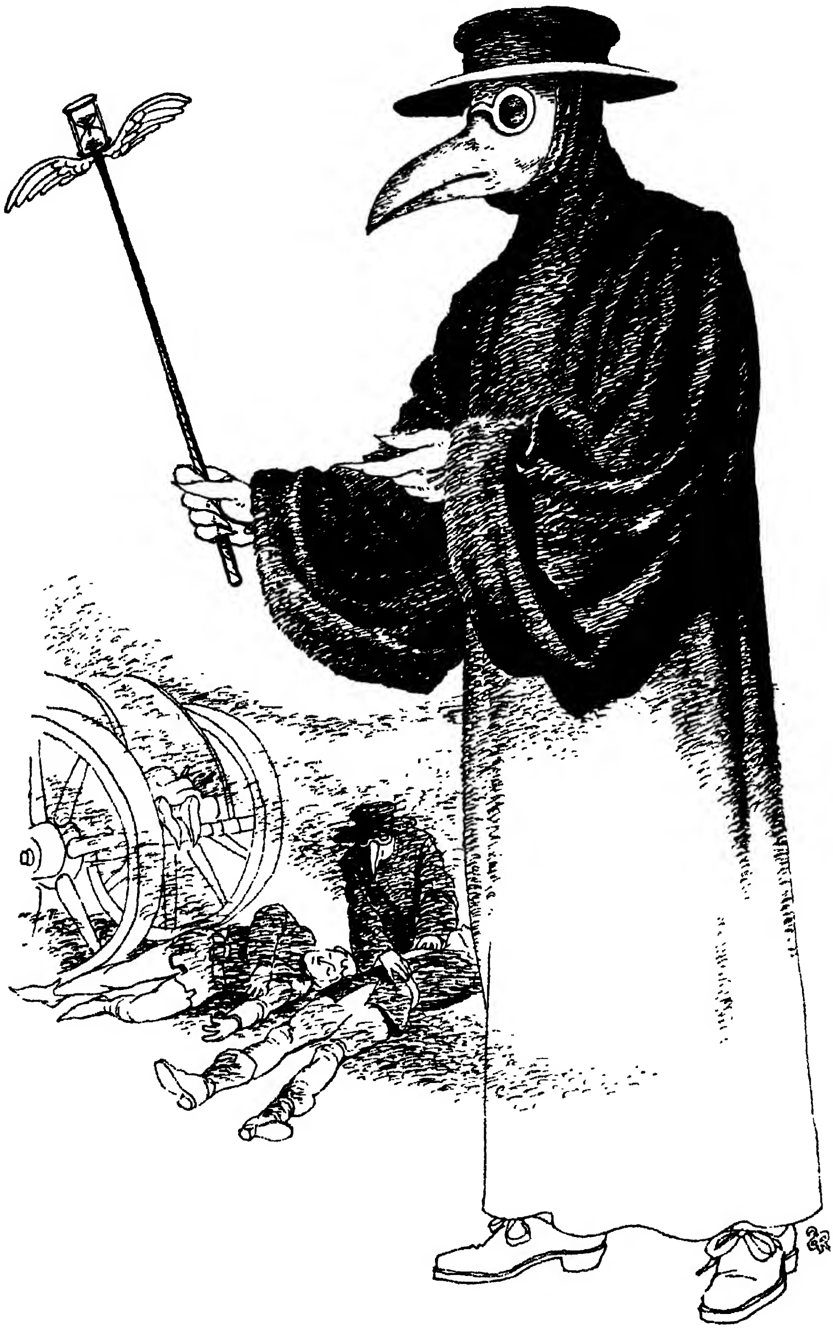
For such quaint advice the patients came to the little town on the blue bay of Salerno. And some, at least, must have left there cured of their maladies.

The school at Salerno marked a step forward in the long history of the physician's work. Here an anesthetic was discovered, and, though it was forgotten later, it brought release from pain for a time, at least. Here it was recognized that a physician must take a definite course of training. And here for the first time in history a man who had been trained was permitted to call himself "doctor."

Small beginnings these, with leprosy and plague and all manner of other diseases raging—yet they were the first faltering steps toward an established medical profession.

As the years passed, the school at Salerno diminished in its importance. Rival medical schools grew up at Bologna in Italy and at Montpellier in France and at the University of Naples. Finally, in 1811, the Salernian school was dissolved by an edict of Napoleon.

But in the long run, Napoleon's edict did not matter. The school at Salerno had made its great contribution.



VIII. WITHOUT THE HELP OF DOCTORS

MOST of the people of Europe in the Middle Ages had never heard of the school at Salerno, and had no idea of the medical profession which the doctors there were struggling to establish. For them disease was a scourge sent by God, to suffer and bear as best they might.

Leprosy was one of the diseases people feared most. Lepers were to be seen in almost every street, and the terrified people often met them wandering through the countryside. Many had tried to cure leprosy. Hildegard of Bingen in Germany, for example, recommended an ointment made of unicorn's liver mixed with white of egg. She even told how to capture the unicorn, using a young woman as bait.

But the number of lepers continued to increase, and, after a while, an effort was made to shut them up in hospitals called "leprosias" or "lazar houses" (there was an idea that Lazarus had suffered from leprosy—hence the name).

To incarcerate such large numbers of people was, however, utterly impractical. In most places, therefore, the leper was required to carry a rattle, which he shook when a passer-by approached; to wear a special distinctive dress; and to avoid touching any object offered for sale, although

he might point at it with his stick. He was also forbidden to speak to anyone unless he walked around to the lee side of him, and he might never enter any church or bakery, or any room where others sat. Saint Francis of Assisi and Saint Elizabeth of Hungary were among the only ones who did not shun the lepers, and even these brave souls knew of no way to help or cure them.

While the people of Europe were looking with terror at the lepers, with their rattles and their begging bowls, a more deadly scourge swept across the land. This was the bubonic plague. It was spread by fleas that lived on rats which were brought to Europe from the East in the holds of sailing ships. People called the disease the Black Death.

It was thought that the Black Death originated in China at a time when, according to the Chinese chronicles, floods, earthquakes, and meteors held the people in terror. Many believed that these were omens of the plague. The sickness spread westward from China along the caravan routes, and soon it broke out in central Asia and along the Black Sea, in India, in Constantinople, Bagdad, Arabia, and Egypt. The sailors on the ships sailing down into the Mediterranean were affected with it. It was found in Sicily, Cyprus, Sardinia, Corsica, Marseilles, and Genoa.

Twelve Genoese galleys sailing from Constantinople to the port of Messina brought the disease with them, and Michele de Peazza, a Franciscan monk then in Messina, wrote:

> The infection attacked everyone who came in contact with the patient. The infected person felt a severe pain boring through his whole body and was badly shaken. Then there appeared a pus-

tule [a small elevation of the skin, containing pus] as large as a lentile on the thigh or arm which the people called carbuncles. These infected the body and spread through it so that the patient spat up blood violently. . . . As the people of Messina realized that the sudden death came to them from the Genoese ships they drove them with great haste from the harbor and the city.

So the ships sped hastily from Messina to Genoa, and from Genoa to Venice, and everywhere they went, they carried the infection with them.

The Black Death appeared in France in 1348, carried there by ships from Genoa, and Guy de Chauliac, a well-known French physician trained at Salerno, announced that the disease had two causes; the conjunction of Jupiter, Saturn, and Mars; and the weakness of those whom it attacked. He ordered that the Pope, who was then at Avignon, "should be shut up in his own chamber wherein great fires were kept constantly burning and access was given to no man."

In some places it was thought that the Jews had poisoned the people, and large numbers of Jews were killed. Elsewhere the blame was attached to cripples, or to the nobility, so that neither of these groups dared to go abroad.

No one knows exactly how many people lost their lives during this epidemic of the Black Death. Some historians assert that it was three-quarters of the whole population of Europe. There was not room to bury all those who died, so in many places trenches were dug and corpses heaped into them. At Avignon the Pope consecrated the River Rhone so that bodies might be thrown into it.

One of the most vivid descriptions of the dreadful illness has come to us from Boccaccio, who lived in Florence at the time, and described it in his *Decameron.*

"How many valiant men, how many fair ladies, breakfasted with their kinsfolk, and that same night, supped with their ancestors in the other world," he wrote.

And: "The condition of the people was pitiable . . . they sickened by the thousands daily and died unattended and unsuccoured. Many died in the open street; others dying in their houses made it known that they were dead by the stench of their rotting bodies."

Since treatment for those stricken was unavailing, an effort was made to detain ships from the East, which were thought to carry the infection. Travelers coming from this direction were held in special ports for thirty days, and later for forty days. *Quaranta giorni,* the law read— it was the beginning of the practice of quarantine.

A few physicians went among the people, wearing long leather coats as a protection. They also wore masks with long wooden beaks in which they inserted a sponge dipped in vinegar to protect themselves. But they could do nothing against the onslaught of the Black Death. The people turned from them to the Church and lighted candles at the altars of the saints. But the saints, too, seemed unable to help. There was apparently nothing that could be done. The disease ran its course, killing those who were least strong, and left an exhausted and terrified Europe to cope with the difficulties that lay ahead.

Hardly had the ravages of the Black Death subsided, when

a strange new affliction possessed the people. In the city of Aachen on an afternoon in 1374 a group of people joined hands and began to dance in a circle and sing. The sound of their singing brought others running from the neighboring houses, and soon the street was filled with men, women, and children, joining hands and dancing round and round for hours at a time.

"Peasants left their plows, mechanics their workshops, housewives their domestic duties, to join the wild revels. . . . Girls and boys quitted their masters to amuse themselves at the dances of those possessed . . . ," says one historian. The only explanation of the strange behavior of the dancers was that the devil had possessed them.

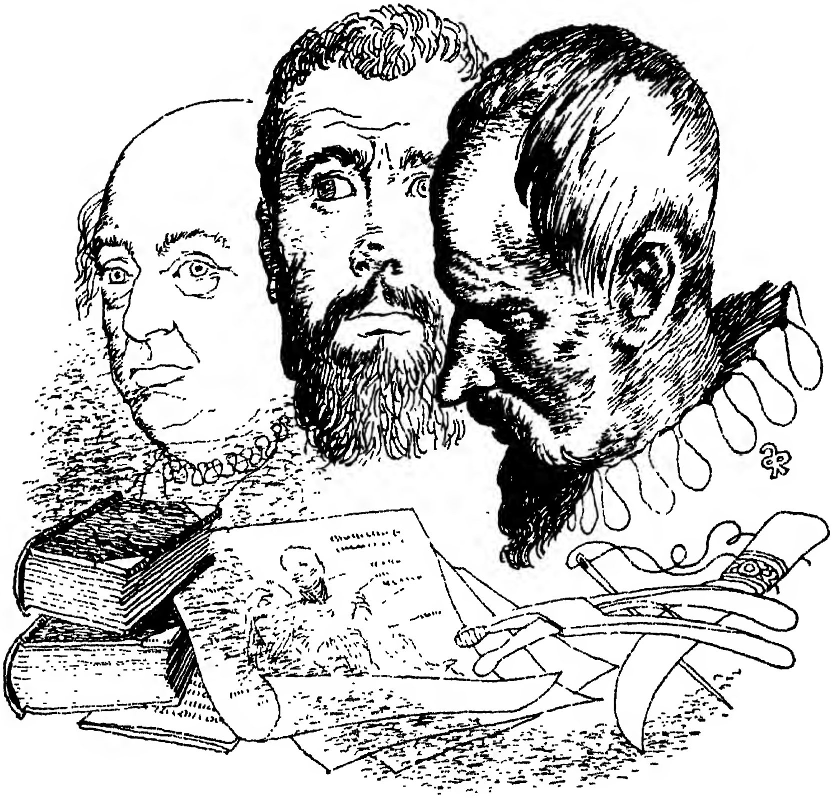
From Aachen the dancing mania spread to Liége, and then to Utrecht, and Cologne, and Metz. Everywhere physicians and councilmen and the parents of boys and girls watched with consternation as the dancers swirled along the streets.

At Strasbourg the town council decided to take active measures against the peculiar malady. They laid hands on the dancers, divided them into small groups, and took them to the chapel of Saint Vitus, where priests tried to cure them with masses and other rituals.

In Italy the Dancing Mania was thought to have been caused by the bite of a spider, the tarantula, and people called the dance the "tarantella." But no one knew what really brought on the strange mass hysteria. It apparently had no relation to chorea, the disease which we now call Saint Vitus's Dance. This malady seems to be related to rheumatic fever and is infectious in its origin.

But just as the scourge of leprosy gradually died down, and the terrible Black Death ran its course, so the Dancing Mania gradually subsided. And it cannot be claimed that either priest or physician had much to do with its abatement.

There were to be many more years of suffering before the healing art of the physician could bring the people comfort.



IX. THREE BOLD MEN

WHILE the Black Death was raging, doctors were scarce enough in Europe. The few there were, were scholars who had studied the writings of Galen in the original Latin and who still believed that sickness was caused by a disproportion of the four humors. People called these, "doctors of the long robe," to distinguish them from the barber

surgeons, or "doctors of the short robe," who were not nearly as respected. "Doctors of the short robe" practiced leeching and bleeding and went around with traveling fairs. There they undertook to remove kidney stones or sometimes to amputate legs—they stopped the bleeding by applying a red-hot iron. But neither doctors of the long robe nor those of the short did much to alleviate suffering or to cure sickness. They followed the traditional customs, and were content with that. So it went on, year after year, spring, summer, autumn, and winter, each season bringing its allotment of sickness and pain.

But imperceptibly a change came in the old ways, as here and there people began to question them. Whatever it was that set the men of the Renaissance to exploring and inventing, digging up the treasures of antiquity and sailing into unknown seas, building and painting and writing poetry—that surge of eagerness and curiosity penetrated the fields of medicine and surgery too.

And three men, who differed in every other way, were alike in this—they dared to break with tradition, to cast aside old ways, to trust their own judgment and common sense.

Put down the names of Paracelsus, Ambroise Paré, and Andreas Vesalius, therefore, as the names of three very great men: Paracelsus, who exploded the old theory of the "four humors"; Paré, an imaginative surgeon who abandoned the use of burning oil in treating wounds; and Vesalius, whom some medical historians have called the greatest of the anatomists. Perhaps there have been no more adventurous men than these in the entire history of medicine.

Of the three, Paracelsus was born first. His real name was Theophrastus Bombastus von Hohenheim, but he called himself Paracelsus—meaning that he was greater than Celsius, a famous Roman encyclopedist.

Paracelsus's father could not afford to give him an education. The boy never went to school. But he learned something about astrology from his father, and something about necromancy. These enabled him to support himself as he traveled all through Europe and over into Egypt and out as far as Samarkand in Persia. For a time he lived with Sigismund Fugger, the rich owner of mines in the Austrian Tirol; then he dabbled in metallurgy and alchemy and searched for the philosopher's stone—the stone which was reputed to turn other metals into gold.

Wherever Paracelsus went, he tried to produce cures, and these, strange to say, were very successful. Before long, though he had never studied medicine, all the great men of Europe came to consult him, and he could boast that he had cured thirteen princes whose cases had been pronounced incurable. The famous Erasmus consulted him about kidney stones, and he cured the great printer Johann Froben of gout.

So great was his renown that at the age of thirty-three he was invited to be professor of physic and surgery at the University of Basel in Switzerland ("Physic" was the old term for the study of medicine.)

There must have been great excitement in Basel the day the new professor began to teach. In the first place, he was to lecture in German. All medical teaching had up to that

time been in Latin, so the other doctors thought that medicine was suffering a great indignity at his hand.

And while the students crowded into the university's big theater, Paracelsus did another radical thing. He took the books of Galen and of Avicenna and set them on fire.

"They are good for nothing," he said to his students. "You will not need them. Reading never made a physician. . . . Patients are the only books." Then he shouted, "You shall follow me! The monarchy of medicine is mine!"

What was it that this self-appointed monarch of medicine taught his startled students? He denied the old theory of humors that Hippocrates and Galen had taught, saying that sickness did not depend on an excess or deficiency of bile, phlegm, or blood. Sickness was "an actual existence," he said, "a blight upon the body, subject to its own laws, and to be opposed by some specific medicine." In his researches and wanderings he had found many remedies. He was the first to use opium, mercury, sulphur, iron, and arsenic in the treatment of various diseases.

Naturally the other physicians hated him for his boastful and radical ways. They said he drank too much and that he went to bed with his clothes on. Finally he treated a high Church official for gout by giving him laudanum. When the cleric appeared to be better, Paracelsus demanded the fee that had been agreed upon—one hundred florins. The cleric refused to pay, and Paracelsus abused him; the case was taken to court and, as was to be expected, the verdict went against the doctor.

So Paracelsus took up his wandering life again. Every-

where he went he argued and fought. He died, having been pitched from an inn window by the servants of an indignant count with whom he had quarreled.

The account of his death has been denied by some of his contemporaries, but the fact of his violent and boastful nature remains.

And this more important fact remains—he thrust aside Galen, daring to say that the old theory of humors was wrong; that there were specific remedies for specific diseases; that he had found some of them; that there were doubtless others to be found.

Ambroise Paré was an entirely different kind of man, yet what he did was revolutionary too. He was willing to try new ways of healing and, in trying them, he made new discoveries.

Paré was a French military surgeon. He first came into prominence when Francis I of France, ambitious to rule over parts of Italy to which he claimed inheritance, sent an army down across the Alps in 1536 to claim the Duchy of Milan, where the duke, Francesco Sforza, had recently died. Paré was with that army, serving as surgeon under Maréchal de Montejan, the Colonel-General.

He had a passion for his profession and had managed to get himself a good medical education, though his father was a poor man, a trunk-maker in the town of Laval in the province of Mayenne, France. Since the elder Paré could not afford to give his son a literary education, he had apprenticed him to a barber surgeon, and Paré had worked with great diligence and enthusiasm, finally making his way to

Paris, where he worked in the Hôtel Dieu, a great French hospital. After a while he was admitted to the College of Surgeons, where his colleagues were inclined to look down on him, for he knew no Latin, and Latin was the sign of an educated man.

When this rather obscure Ambroise Paré was invited to take part in the Italian campaign, he set out eagerly. So skillful and gentle was he in his care of the wounded and sick that he became very popular with the soldiers.

It was the custom among them when a man was seriously hurt or wounded on the march to slit his throat in order that he might not fall into the hands of the enemy, where he would fare much worse. Once when they were about to dispatch a wounded soldier in this way, Paré bound up the man's wounds and persuaded his fellows to carry him along with them. When the soldier recovered, there was exultation in the camp, and the men, who were themselves very poorly paid, showered coins into a battered helmet as a gift to Paré.

At the beginning of the sixteenth century gunpowder was coming into general use, and the effect of its poison on wounds was greatly feared. Paré, as was the custom of the day, used to pour boiling oil on the gunshot wounds before he dressed them. One evening after a heavy engagement he found that his supply of oil was exhausted, and he still had many men to treat.

He wrote:

> At length my oil lacked, and I was constrained to apply in its place a digestive made of the yolks of eggs, oil of roses, and turpentine. That night I could not sleep at my ease, fearing that

by lack of cauterization I would find the wounded upon which I had not used the said oil dead from the poison. I raised myself very early to visit them, when beyond my hope I found those to whom I had applied the digestive medicament feeling but little pain, their wounds neither swollen nor inflamed, but having slept through the night. The others to whom I had applied the boiling oil were feverish, with much pain and swelling about their wounds. Then I determined never again to burn so cruelly the poor wounded by arquebuses.

Later, at the siege of Danvilliers, Paré made another discovery. There it became necessary to amputate an officer's leg. Instead of applying a red-hot iron to stop the bleeding, Paré found that the flow could be stanched by tying the severed arteries. He was not the first man to try tying the arteries, but he was the first to make it a customary procedure, and the practice has been followed ever since.

"I dressed him and God healed him," Paré said of the officer whose leg he had cut off. "He returned home gaily with a wooden leg, saying he had got off cheaply, without being burned miserably to stanch the bleeding."

Paré did not spend all his life with the army. He went to Paris in his middle years, where he treated large numbers of rich and important people. Except for the soldiers, rich people were the only ones in those days who could afford the luxury of a physician. Paré had four French kings among his patients—Henry II, Francis II, Charles IX, and Henry III.

It was at the bedside of Francis II, who had been fatally wounded by a lance in a tournament, that he met Andreas Vesalius, the Flemish anatomist.

No record shows whether the great French surgeon and Vesalius recognized kindred spirits in each other as they leaned over the body of the dying king. They were trying unsuccessfully to trace the course the fatal lance had taken. After the monarch's death each man went back to his practice, as did the other renowned physicians who had been called. Yet, if they had stayed long enough to talk together, it is almost certain that they would have been congenial. For both men had in them that brilliant, curious spark, compounded of daring, curiosity, and adventure, that marked the men of the Renaissance in so many fields.

Andreas Vesalius, born three years before Paré, was the greatest of the three great physicians of the Renaissance. He had studied the classics at the University of Louvain, and had listened to lectures on anatomy and medicine under the most eminent teachers of the times at Cologne, Montpellier, and Paris--for in his day there were other medical schools besides that at Salerno. What interested him above all else was anatomy. This had been so since he was a boy.

Just as Paracelsus had rebelled against teaching from books and told his pupils that they must learn from observing their patients, so Vesalius was sure that anatomy could be learned only by dissecting the human body. To obtain bodies for dissection was almost impossible at that time; he had to resort to stealing bodies of criminals that had been executed on the gallows.

His work in dissection soon drew wide attention, so that before long he was invited to be professor of anatomy at the University of Padua—the great scientific center of his day.

Here in a small and richly decorated amphitheater he gave demonstrations before a throng of some five hundred students. Other professors had been accustomed to read their lectures in Latin, but he used English. They pointed to the various bones, joints, muscles, veins, and nerves, while a barber surgeon did the dissecting. Vesalius, however, took the knife into his own hand, laying open the various parts with a skill and delicacy that were the admiration of all who watched.

Vesalius did all his lecturing at Padua before he was thirty. And for three years while he was there he collected his lecture notes in a book which he called *The Fabric of the Human Body*.

The Fabric of the Human Body has been called a "glorious" book. It is written in Latin, describing, part by part, bones, joints, muscles, veins, and nerves. It is illustrated with woodcuts which were made in Italy and carried to Basel by a merchant named Danoni, who delivered them to the printer. The wood blocks were accompanied by a long letter in Latin in which Vesalius urged the engraver to take the greatest care.

"Every detail must be distinctly visible," he wrote, "so that each cut shall have the effect of a picture."

Early the next year Vesalius went to Basel himself to superintend the printing.

It is a curious fact that although a great deal is known about the printing of the book, no one knows for certain who the artist was who made the beautiful illustrations. Vesalius relates that he tired himself out directing the artist's eye and

his hand, and says that the man was "stubborn." Perhaps they had some quarrel. At any rate, the artist's name is not to be found anywhere in the book. For a long time people thought the pictures might have been made by Titian, but now most scholars agree they were done by Jan von Calcar, one of Titian's pupils.

In the beautiful book on which Vesalius spent so much care and money he taught the people of his time not to rely on authority, not to believe a statement was true because Galen had said it, but to examine and to study for themselves.

After Vesalius's book was published, a storm of controversy broke out. Many young men stood by Vesalius, but all the established and well-known doctors were horrified, and one of his old teachers called him a "madman"; for his conclusions in many instances had disagreed with those of Galen.

Vesalius was in despair. He had spent his fortune and all his enthusiasm on *The Fabric of the Human Body*. Now in desperation he took his notes on Galen, and other material which he had collected for future books, and burned them.

When an opportunity came to give up teaching and to serve as court physician to Emperor Charles in Madrid, he took it. He had revolutionized the study of anatomy, but very few people recognized that fact. He died in discouragement in 1564. A contemporary letter gives an account of his death.

They say that Vesalius is dead. Doubtless you have heard he went to Jerusalem. That journey had, as they tell us from Spain,

an odd reason. Vesalius, believing a young Spanish nobleman whom he had attended to be dead, obtained leave of the parents to open the body, for the sake of inquiring into the cause of the illness, which he had not rightly comprehended; but he had no sooner made an incision into the body than he perceived the symptoms of life, and opening the breast saw the heart beat. The parents, coming afterward to the knowledge of this, were not satisfied with prosecuting for murder, but accused him to the Inquisition of impiety, in hopes that he would be punished with greater vigor by the judges of that tribunal than by those of the common law. But the king of Spain interposed and saved him on condition that by way of atoning for the error he should undertake a journey to the Holy Land.

So Vesalius made his journey to the Holy Land to save himself from torture by rack or thumbscrew. His ship was wrecked by a violent storm on the return journey and he died off the island of Xanthus in the Aegean Sea.

X. MR. DOCTOR HARVEY LOOKS AT THE HEART

ONE of the most prized possessions of the British Museum in London is a little pointer made of whalebone and tipped with silver. It is the pointer that William Harvey used in the seventeenth century when he first demonstrated the movement of the heart and the circulation of the blood.

Mr. Doctor Harvey, as people in London called him, had studied the heart, the arteries, and the veins for many years

before he was able to demonstrate the circulation of the blood with his silver-tipped rod. He had first been interested in the veins and the arteries when, as a young man, he had enrolled at the University of Padua in Italy.

Padua was the great scientific center of Europe in Harvey's day. Here Galileo taught mathematics and astronomy, and here the great Fabricius, successor to Vesalius, lectured on surgery and anatomy. To say that he had studied at Padua was the ambition of every man who had scientific aspirations. Five thousand students from every part of Europe registered for the courses there.

Naturally, therefore, William Harvey, whose ambition it was to be a doctor, went to Padua for his training. The son of the prosperous mayor of Folkestone, he left England in 1597, and when he reached the old city in northern Italy he already had the rudiments of a good education. He had been to school in Canterbury and had studied at Caius College in Cambridge. He could read and write Latin as easily as he could English, and loved to quote Vergil, his favorite poet. Now he was to crown all this learning with the best scientific training in Europe. Then he would practice.

The quadrangles of the University of Padua are surrounded with arcades where walls and ceilings are covered with the *stemmata,* or coats-of-arms, of foreign students, and here the young William Harvey had his own *stemma* painted in bright colors. It is an oval shield on which is pictured an arm and a hand bearing a lighted candle. Around the arm two serpents twine, and over it the word "*Anglica*" is written. The shield may be seen there still.

The great Fabricius was the man whose lectures Harvey anticipated most eagerly. Fabricius gave his demonstrations in a little amphitheater that the government had recently erected especially for him. The amphitheater had circular galleries with high, carved oaken railings behind which the students stood to watch. The tiers rose almost straight to the roof, and since there were no windows Fabricius gave his demonstrations by candlelight. The subjects that he anatomized were brought up through a trapdoor from the basement, where they had been prepared.

Fabricius showed the students, peering down over the railings, the mystery of the muscles, bones, nerves, arteries, veins, and organs of the human body. He spoke often of the "little doors," or valves, of the veins, about which he had written a book, but whose function he did not clearly understand. Harvey was to remember those lectures all his life.

Harvey was awarded his M.D. in April 1602, and returned to England. His days were filled with achievement after he reached home. He received an M.D. from Cambridge in 1604, and in that same year married Elizabeth Browne, the daughter of Dr. Lancelot Browne, physician to Queen Elizabeth. Little is known of her save that she was "tall, of dark complexion, and of somewhat severe aspect," and that she was devoted to her parrot.

And now Mr. Doctor Harvey, as he began to be referred to, was appointed assistant physician at the famous London hospital, St. Bartholomew's. He was obliged to attend patients there "one day each week throughout the year." This he did in the hall of the hospital, which was heated by a

great fireplace stoked with wood from the royal forest at Windsor.

Besides his hospital work, Harvey had a large private practice. He rode out to see his patients on horseback, with two manservants running behind. But when he went to visit King James I, who had succeeded Queen Elizabeth, his men spread out a cloth so that he might walk on it from the carriage to the palace.

Sometimes Harvey stopped his work long enough to drink coffee with his brother Eliab, or to talk with one of his four other brothers. Sometimes he stopped to chat with his colleagues at the College of Physicians before he went home to sup and to spend the evening in his own library, reading Aristotle or Galen, and dropping off to sleep at last over his favorite Vergil.

Harvey's friend John Aubrey, the English antiquary, wrote in his *Memoirs:*

> He was, as were all the rest of the brothers, very cholerique [of hot or fiery nature]: and in his younger days would be apt to draw out his dagger upon every light occasion. He was not tall. but of the lowest stature; round-faced, olivaster (like wainscott) complexion; little eie, round, very black; full of spirit; his hair was black as a raven, but quite white 20 years before he died.

By 1615 Harvey had become eminent. That year he was invited by the College of Physicians to be Lumleian lecturer on anatomy and surgery. These lectures were founded in 1561 by Lord Lumley and Dr. Richard Caldwell, and are still given.

In Harvey's time the lectures were to be held twice a week

throughout the year. Each one was to be an hour long, three-quarters of an hour in Latin and one-quarter of an hour in English. The lecturer was also required each year "to dissect all the body of a man for five days together, as well before as after dinner; if the bodies may last so long without annoy."

The notes that Harvey used for the Lumleian Lectures may still be seen in the British Museum. They are written in a queer crabbed hand, very difficult to decipher. Here and there red ink is used, though for the most part the ink is black. English and Latin are intermingled in the notes in a confusing way. Sometimes a sentence starts in English, drops into Latin, and then falls back into English again. A large part of the notes are on the movement of the blood in the veins.

In Harvey's notes is to be found the first statement of his great discovery on the circulation of the blood.

> On account of the structure of the heart, William Harvey is of the opinion that the blood is constantly passed through the lungs into the aorta, as by two clacks of water bellows do raise water. Moreover, on account of the action of a bandage on the vessels of the arm he is of the opinion that there is a transit of blood from the arteries to the veins. It is thus demonstrated that a perpetual motion of the blood *in a circle* is brought about by the beat of the heart. What shall we say? Is it for the purpose of nutrition? Or is it for the better preservation of the blood and of the members by imparting heat to them, the blood by turns losing heat as it warms the members, and gaining heat from the heart?

Harvey had made his discovery not by guesswork or theorizing but by studying the structure of the heart, by experi-

menting—by tying the arteries, by watching the pulsing of the blood in the veins and arteries and relating this movement to the expansion and contraction of the heart itself. These were the things that he demonstrated, pointing with the silver tip of his little whalebone wand.

He was in no great hurry to publish his discovery, however. He once said, "The crowd of foolish scribblers is scarcely less than the swarms of flies in the height of summer, and threatens with their crude and flimsy productions to stifle us with smoke"; and he did not want to be a "foolish scribbler."

Not until 1628, twelve years after his first statement on the circulation of the blood, did Harvey publish his little book, *On the Circulation of the Blood.* It has been called the greatest book in medical literature.

The book is only seventy-two pages long, poorly printed on paper that is beginning to crumble. Harvey sent his manuscript to Frankfurt, Germany, to be printed, perhaps because he thought that the annual book fair there would help give it publicity.

The book opens with a graceful dedication to King Charles I, who had by this time ascended the throne. Harvey compares the king to the heart, the center of all strength and power, and says, "The knowledge of his own Heart cannot be unprofitable to a King."

The first part of the book describes the views of earlier anatomists concerning the heart and the blood: how they regarded the liver as the central blood organ; how blood was manufactured there from food taken into the body; how

the blood moved to and fro in the body, drawn back and forth by the dilation of the heart and arteries.

"But I have studied the heart," we can imagine Harvey saying to himself, "not only in man but in the animals. The heart is a hollow muscle, and blood pushed into the arteries gives rise to the pulse. It is like a flintlock flint striking steel, which ignites the powder, causes an explosion, and ejects the bullet, all in the twinkling of an eye."

Where does the blood come from? Where does it go? By carefully tying the arteries and the veins at different points and watching the results, he calculated the amount of blood expelled at each heartbeat.

He wrote in his notebook:

> And not finding it possible that this could be supplied by the juices of the ingested aliment without the veins on the one hand becoming drained, and the arteries on the other getting ruptured through the excessive charge of blood, unless the blood should somehow find its way from the arteries into the veins, and so return to the right side of the heart; I began to think whether there might not be *a motion as it were in a circle.*

How the blood managed to make its way from the ends of the smallest arteries to the tips of the smallest veins Harvey had no way of seeing. The discovery of the capillary system was left for Malpighi in 1651, looking at a frog's leg through his microscope. Later Leeuwenhoek saw the tiny blood corpuscles passing through the capillary system.

"How did you happen to think of the circulation of the blood?" the Irish scientist, Robert Boyle, asked Harvey afterward.

And Harvey wrote:

Since the Blood could not well, because of the interposing Valves, be Sent by the Veins to the Limbs; it should be Sent through the Arteries, and Return through the Veins, whose Valves did not oppose its course that way.

There was a falling off in his practice when Harvey's book was published. Perhaps his patients did not like to have a doctor with strange new notions; one whose idea of the functioning of the body was based on scientific observation and experiment was still not to be trusted.

John Aubrey wrote:

I have heard him say that after his booke on the Circulation of the Blood came out, that he fell mightily in his practize, and that 'twas believed by the vulgar that he was crack-brained; and all the physitians were against his position and envyed him.

But the loyal friend stated later, "With much adoe at last, in about 20 or 30 yeares time, it was received in all the Universities of the world."

Perhaps the recognition of his achievement or the lack of it did not matter greatly to William Harvey. He had gone on to study embryology. "All things come from the egg," he announced. He kept a laying hen in his chamber in order that he might study the changes in the eggs from day to day.

John Aubrey wrote that as Harvey grew older:

He was much and often troubled with the gout and his way of cure was thus: He would sit with his legs bare, though it were frost, on the leads of Cockaine House, put them into a pail of water till he was almost dead with cold, then betake himself to his stove, and so 'twas gone.

And in another place Aubrey commented:

His thoughts working would many times keep him from sleeping, in which case his way was to rise from his bed, and walk about his chamber in his shirt till he was pretty cool, and then return to his bed, and sleep pretty comfortably.

And again the old friend wrote: "He did delight to be in the dark, and told me he could then best contemplate."

Harvey lived to be almost eighty years old. Before he died he wrote a passage in his book, *Essays on Generation of Animals*, which deserves to be remembered.

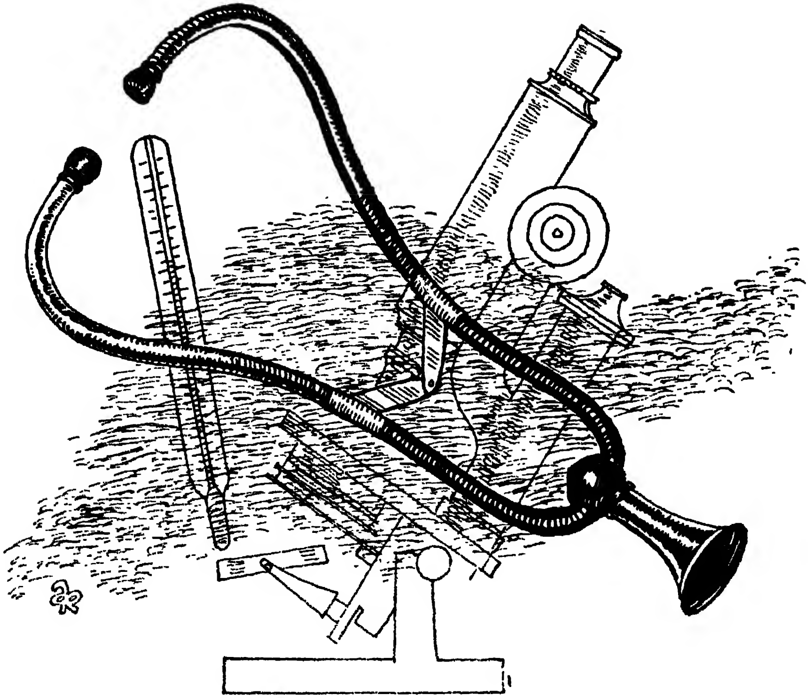
The eternity of things is connected with the reciprocal interchange of generation and decay, and as the sun, now in the East and then in the West, completes the measure of time by his ceaseless revolutions, so are the fleeting things of mortal existence made eternal through incessant change, and kinds and species are perpetuated though individuals die.

William Harvey made his will in the winter of 1657. He wrote it in the same crabbed hand in which he had written his lecture notes many years before. But this time it was all in English. Among the many items mentioned in that document was one providing for his fellow doctors at the College of Physicians.

All my bookes and papers and my best Persia long Carpet and my blue sattin imbroydyed Cushion, one pair of brasse Andirons with fire shovell and tongues of brasse for the ornament of the meeting roome [of the College of Physicians]. . . . Item. I give my velvet gowne to my loving friend Mr. Doctor Scarborough desiring him and my loving friend Dr. Ent to look over those scattered remnant [sic] of my poore Librarie and what bookes,

papers or rare collections they shall thinke fit to present to the Colledge and the rest to be sold and with the money buy a better. And for their pains I give to Mr. Doctor Ent all the presses and shelves he please to make use of and five pounds to buy him a ring to keep and weare in remembrance of me. And to Mr. Doctor Scarborough All my little silver instruments of surgerie.

The author of the great book *On the Circulation of the Blood* died on the third of June, 1657. His body was laid in a vault at Hempstead, in Essex. A large number of Fellows of the College of Physicians followed it to the vault. For by that time his achievements had been recognized



XI. THERMOMETERS, STETHOSCOPES, AND OTHER TOOLS

WILLIAM HARVEY made his great discovery in the seventeenth century, but many doctors would not believe that the blood circulated in the body, for there is always a lag between the discovery of a new idea and its acceptance. Nevertheless, Harvey's work and that of Vesalius started a new thing in European medicine: the idea that an understanding of physiology was necessary for the physician.

Now, in the same century, another new idea came into

being—the idea that the doctor needed tools to help him in his work. Up to that time doctors had had to work without clinical thermometers, without ways of timing the pulse or measuring a person's metabolism, without any satisfactory method of listening to the sounds that tell of disorders of the heart and lungs. Doctors without these things were like artists without paintbrushes, like carpenters without planes and drills.

There was a great deal of sickness at this time. People were sorely plagued with epidemics. Scurvy raged throughout northern Europe. Malaria sapped the strength of the people of Italy. There were epidemics of typhus in France, Germany, and the Low Countries. And the bubonic plague returned again, killing half of the people of Lyon in 1628, spreading through Holland and Germany, killing sixty-five thousand people in Genoa in one year, a hundred thousand in Vienna and as many in Prague, and making London a city of terror and misery.

Nor were these the only epidemic diseases which the people had to dread. Smallpox was rampant throughout Europe and also in the new settlements of America. There were epidemics of dysentery, of measles and scarlet fever. And diphtheria appeared for the first time. "England is like a great hospital," one writer said. And that description must have been equally true of other countries, where the people were terrified at the manifestations of disease and knew no real way to combat them.

There were many honest, hard-working physicians in those miserable times who knew the ancient texts of Hippocrates

and Galen and could administer a few drugs. These doctors were accompanied on their rounds by barber surgeons, who bled the patients under their direction. But even the best of these doctors could do very little with the understanding and the appliances at their disposal.

And for every honest doctor there were half a dozen charlatans. Very pretentious and self-important, they would enter the patient's room to deliver a harangue and write out a long prescription that included all sorts of things whose properties no one, including the doctor, knew anything about.

Molière, the French dramatist, was forever lampooning the medical profession, and perhaps the barbed passages in his plays were well founded. Physicians in those days were pompous, grandiloquent, and generally ignorant, according to Molière. But it may be that a doctor had these qualities because the knowledge of the time gave him no opportunity for a more intelligent approach.

In lieu of more efficient cures, many people, particularly those in England and France, besought their king to heal them with what they called "The Royal Touch." This they thought particularly efficacious in skin diseases. So the kings made journeys through their kingdoms, and wherever they chose to stop, large numbers of people came and knelt before them, believing that if the monarch placed his hand on them they would be healed.

Nevertheless, the scientific spirit was beginning to stir in the seventeenth century. People who had explored new seas and colonized new continents, people who had begun to

explore the skies after Galileo had made his telescope and who were marveling at the life of the infinitely small which Malpighi and Leeuwenhoek showed them through their microscopes, were beginning to want scientific explanations for what they saw. Some of them were discussing what they called "the true nature of things" and casting aside reverence for what they did not understand. They were giving up their fears of the stars and of the devil, and trusting to their own intelligence. Some of them were forming societies where the latest scientific theories were discussed. The Royal Society of London, which was organized by Charles II in 1660, was outstanding among these.

It was natural that in the field of medicine, too, there should be a new effort to experiment, and efforts at experimentation led naturally to invention. The faint, first beginning of the great age of modern scientific medicine had started.

Sanctorius Sanctorius began it. Over the door of the modest house where he lived in Capodistria, Italy, there is an inscription which reads, "The first famous master of experimental medicine."

Sanctorius Sanctorius developed his interest in medicine very early, for he entered the University of Padua when he was only fourteen. There he formed a friendship with the young astronomer Galileo that was to last till both were old men. Sanctorius left Italy to become physician to Maximilian, king of Poland, but he corresponded with Galileo, and the intimacy was resumed when he returned to Italy again.

It was natural that the two men should be congenial,

though Galileo's interest was in physics and astronomy, and Sanctorius's in medicine. The doctor was forever trying to adapt the instruments that the physicist made into precision instruments for use in medicine. Between them they must have had great discussions and arguments.

Once Galileo watched the swinging of a chandelier in the Cathedral of Pisa, and, putting his finger on his wrist, found that his pulse beat in the same rhythm. He pointed this out to his friend Sanctorius, who also counted the beat of the pulse by the swing of the chandelier, and afterward by a pendulum. Now he found that the speed of the pulse beat could be expressed in terms of the length of the pendulum, and he made a little instrument to measure the pulse beats. He called this instrument a "pulsiologium."

Later Galileo made an alcohol thermometer, which he referred to as "a little joke." But Sanctorius converted this thermometer into a device for measuring fever. And he made three types of it: one with a large bulb to be held in the hand, one with a funnel into which the patient could breathe, and another to be put into the mouth.

These were the first attempts to measure pulses and temperatures accurately.

Meantime Sanctorius was experimenting with other matters. He had hit upon the idea of what physicians nowadays call basal metabolism. He was trying to measure how food taken into the body supplied energy for living. To do this he had a huge pair of scales built. And since he could find no one who would sit on them for his experiment, he sat on them himself. For thirty years he read, studied, ate, and

slept on the great balance without ever stepping to the ground. An old print shows the balance attached by a strong hook to the ceiling, and on this balance the armchair in which Sanctorius was suspended.

It was Sanctorius's practice to weigh himself before various activities. He found that after he had eaten food that had been carefully weighed, and then weighed his body wastes, the weight of these wastes was less than the weight of the food. Part of the food must, therefore, be used up in some other way. He said it was exhaled in "invisible perspiration," which was given off through the skin. The amount of this "invisible perspiration" differed in sickness and in health, Sanctorius said, but not in proportion to the amount of food and drink taken into the body. He believed that if he could compare the weight of his body to the amount of food and drink taken into it, he would have a measure of his sickness or health. Finally, after conducting his experiment, he wrote a book. It is the first work on metabolism.

So the idea of using precise instruments to measure conditions of sickness and health came into being, and as the seventeenth century passed into the eighteenth, new instruments and new procedures appeared. One of the most useful was Leopold Auenbrugger's way of diagnosing conditions inside the human chest. This he called percussion.

Auenbrugger was a physician in the military hospital in Vienna, and a musician who had once written an opera for Maria Theresa, Empress of Austria. The son of an innkeeper at Gratz, he had often tapped the wine casks at his father's inn to determine by the sound the level of the wine inside.

Why should he not find the amount of fluid in a human lung in the same way?

Auenbrugger's book, *Inventum Novum*, announced:

> I here present the reader with a new sign which I have discovered for detecting disease of the chest. It consists of percussion of the human thorax, whereby . . . an opinion is formed of the internal state of the cavity.

Auenbrugger then went on to describe exactly how this percussion should be performed. He told how the chest of a healthy person ought to sound. "It resembles the muffled sound of a drum covered with a thick woolen cloth or other envelope."

He then described the sounds that developed in various diseased conditions.

> The [chest] ought to be struck slowly and gently, with the points of the fingers brought close together and at the same time extended. . . . During percussion the shirt is to be drawn tight over the chest, or the hand of the operator is covered with a glove of unpolished leather. If the naked chest is struck by the naked hand, the contact of the smooth surfaces produces a kind of noise which alters or obscures the natural character of the sound.

Not much attention was paid to Auenbrugger's idea of percussion for nearly twenty years. Then Corvisart, Napoleon's physician, found Auenbrugger's book and translated it into French. That was in 1808, the year before Auenbrugger died. After that percussion was used almost universally, and a doctor, arriving at a patient's bedside, tapped and listened as a regular routine.

Auenbrugger's discovery drew the attention of the doctors to the fact that the sound of breathing varied under different conditions, and that the sound of a beating heart also varied, and that these sounds might indicate various conditions of disease. Often, therefore, the physician put his head down to the patient's chest and listened to the sounds inside. This practice was not very satisfactory, however. Fastidious physicians disliked doing it, and their patients disliked it too.

René Théophile Hyacinthe Laënnec, a short man, thin as a shadow, who came from Brittany, felt a special aversion to putting his head down to listen to his patients' chests. As physician at the Necker Hospital in Paris he had many chest examinations to make. "But sometimes, especially if the patient is very fat, I cannot hear what is going on in his chest at all," he said.

One day, after he had made his rounds at the hospital, he went for a walk in the gardens of the Louvre. It happened that as he was strolling through the park he noticed some children playing. They were divided into two groups, one at each end of a wooden beam. While one group tapped and scratched at one end of the beam, the second group, with ears pressed down to the wood, listened at the other end.

Laënnec watched them for a few minutes and quickly hurried back to the Necker Hospital. He seized a stiff sheet of paper, rolled it into a tube, and tied a string around it. In a ward where a patient was ill with a chest ailment he pressed the tube against the patient's ribs and listened. He could hear the heart sounds and the respiratory murmur

clearly—much more clearly than they could be heard if he had merely pressed his ear against the patient's chest. So he, too, had found a new instrument to help him understand the ailments he had to treat.

After a while Laënnec grew tired of rolling paper into tubes and tying them with string. He learned to work a wood-turning lathe and used rods of either cedar or ebony to replace the rolled-up paper. These were about a foot long and an inch and a quarter in diameter. Later he cut them into two pieces that could be screwed together again. This made them easier to carry around with him.

He could hear the heart sounds very well with the wooden rods, but the murmur of the lungs was harder to distinguish. That was why he made a central canal in the wooden rod. Now he was able to listen to a variety of sounds accompanying various lung ailments. Fascinated, he listened to rubbings, murmurings, and rustlings.

Now Laënnec set to work to identify the diverse sounds he heard and connect them with different diseases of the heart and lungs—the first complete study of its kind that had ever been made.

He called his new instrument a "stethoscope," a term which he combined from two Greek words meaning "the chest" and "to observe."

It remained for later men to improve on his work, until the "binaural" stethoscope finally evolved: a tube that was divided above the bell—which was placed on the chest of the patient—into two flexible tubes that led to the ears of the examining physician.

Laënnec called his process of listening "auscultation." He wrote a treatise which he called *A Memoir of Auscultation,* but no one paid the least attention to it, and doctors who ventured to use the new instrument were looked upon as charlatans.

One English doctor doubted "that it will ever come into general use, notwithstanding its value." And he went on to explain:

> I am extremely doubtful, because its beneficial application requires much time and gives a good deal of trouble both to the patient and the practitioner; because its whole line and character are foreign, and opposed to all our habits and associations. It must be confessed that there is something even ludicrous in the picture of a grave physician proudly listening through a long tube applied to the patient's thorax, as if the disease were a living being that could communicate its condition to the sense without. Besides, there is in this method a sort of bold claim and pretension to certainty and precision in diagnoses, which cannot at first sight but be somewhat startling to a mind deeply versed in the knowledge and uncertainties of our art.

The doctors may have been slow in adopting the new tools and the new methods, but gradually these became a part of every physician's equipment and practice. Crude as the early instruments appeared, they were the forerunners of the many precision instruments used in medical practice today. The observing of the rate and strength of the pulse, the measuring of temperatures and basal metabolism, the tapping of the chest, and the listening with a stethoscope—patient and doctor accept all these now as a matter of course.

XII. A DAIRYMAID GIVES JENNER AN IDEA

SOMETIMES medical discoveries are made after long study and research—perhaps they are most often made that way. But sometimes they are made almost casually, as the result of observation of facts that people have known all along but have taken no heed of, as a result of watching or listening. It was in this way that Edward Jenner made his great discovery of vaccination to prevent smallpox. He listened to the talk of country folk in Gloucestershire, where he was learning to be a country doctor.

Up to Jenner's time smallpox was one of the most terrible scourges that afflicted man. It was known in China and India, in Turkey and Egypt and Europe. It was especially virulent in the American colonies. Sometimes the disease struck lightly, leaving the patient with a face scarred with pockmarks. Sometimes it left him blind, deaf, or insane. One person out of every five or six stricken with smallpox died—it was no wonder that people everywhere dreaded and feared it.

Particularly in the East, doctors had made efforts to prevent or lighten the disease by inoculating healthy persons with lymph taken from those who had already suffered from

it. Lady Mary Wortley Montagu, wife of the British ambassador to Turkey, saw this done in Constantinople in 1716 when she went there with her husband. She wrote an enthusiastic letter to her friend, Mary Chiswell, describing how the inoculation was done.

I am going to tell you a thing that I am sure will make you wish yourself here. The smallpox, so fatal and so general amongst us, is here entirely harmless by the invention of grafting, which is the term they give it.

There is a set of old women who make it their business to perform the operation every autumn, in the month of September, when the great heat is abated. People send to one another to know if there is any in their family has a mind to have the smallpox; they make parties for this purpose, and when they are met (commonly fifteen or sixteen together) the old woman comes with a nutshell full of the matter of the best sort of smallpox and ask what veins you please to have opened. She immediately rips open that you offer to her with a large needle (which gives you no more pain than a common scratch), and puts into the vein as much venom as can lie upon the head of her needle, and after binds up the wound with a bit of shell; and in this manner opens four or five veins. . . . The children or young patients play together all the rest of the day, and are in perfect health to the eighth. Then the fever begins to seize them, and they keep their beds two days, very seldom three. Every year thousands undergo this operation. . . . There is no example of anyone that has died in it; and you may believe I am very well satisfied of the safety of this experiment, since I intend to try it on my dear little son.

After Lady Mary Wortley Montagu came back to England with more talk of the old women and their needles, a great many English doctors began to inoculate their patients

with smallpox serum. But the procedure was not so harmless as it appeared, and the cases so induced were not always light ones—in fact, a number of inoculated persons died. Moreover, it appeared that even the light cases were contagious; there were soon more cases of smallpox in England than there had been for years. Inoculation against smallpox was obviously not the way to stop its spread.

While these grim discoveries were being made, Edward Jenner was growing up in Gloucestershire. The son of a clergyman, he had been carefully educated in the classics by his father. But his real interest lay in the life of the country—in the doings of cuckoos, robins, bats, and porcupines. He liked to write verses, and was especially proud of one called "Address to a Robin," and of another called "Signs of Rain." Poetry and music were equally attractive to him. He loved to sing, and could play both the violin and the flute.

When the time came for young Edward Jenner to choose a career, he decided that he would not leave Gloucestershire. He would be a country doctor who practiced among the farmers.

So he was sent to Sodbury near Bristol, to study surgery and pharmacy under Dr. Daniel Ludlow, and to learn from him how to treat the farmhands, dairymaids, and others who were his patients. Later he polished his education by going to London and working under Dr. John Hunter, an eminent physician.

But it was while he was working as apprentice to Dr. Ludlow in Gloucestershire that his idea occurred. In 1790 a dairymaid came to the surgery for treatment and young

Jenner heard her say, "I couldn't have the smallpox because I have had cowpox."

The remark stayed in Jenner's memory, and he began to investigate further. There was a general belief among the country people that anyone who milked a cow infected with cowpox was rendered immune to smallpox. Yet cowpox, when it was contracted, was a very slight illness and, so far as Jenner could find out, it could not be communicated from one person to another.

For several years Jenner thought the thing over as he rode through the country, paying calls with Dr. Ludlow, or helped with the patients in the surgery.

He wore a bright blue coat at that time, trimmed with brass buttons, and was a little vain about his well-polished jockey boots as he walked about, clanking his silver spurs. Under his broad-brimmed hat his hair was done up in a club.

In 1796 he tried his first experiment in vaccination. A girl named Sarah Nelmes came to the surgery, with her hand infected from milking a cow. Jenner examined the skin of the hand and found small circular elevations that were filled with a clear watery fluid. It was evident that Sarah Nelmes had cowpox.

Carefully the young Jenner extracted a little of the watery fluid and put it into two small scratches on the arm of a healthy boy, James Phipps. Then he waited for several days.

But James Phipps did not become sick. The two small scratches Jenner had made were circled with a red ring—then they healed.

In July Jenner inoculated the boy with lymph from a vesi-

cle of a smallpox patient. To his great satisfaction he found that the boy was immune to smallpox.

It was May 14, 1796, when Jenner made that first vaccination. He wrote soon afterward:

> The joy I felt at the prospect before me of being the instrument destined to take away from the world one of its greatest calamities . . . was so excessive that I sometimes found myself in a kind of revery.

He talked continually of his discovery—but to country people it was no surprise, and the medical men were completely uninterested. In fact, they became so tired of hearing him harp on the same subject that they threatened to put him out of the Convivio Medical Club, as the local medical society was called.

In 1798 he decided to stop talking and publish his discovery in a pamphlet. Its title was given as *An Inquiry into the Cause and Effects of the Variolæ Vaccinæ. A Disease Discovered in the Western Counties of England.* The pamphlet was seventy pages long and had a number of illustrations. In it he explained that cowpox, swine pox, and the disease called "grease" in horses were the same thing, and that lymph developed in these diseases might be used in the prevention of smallpox. He showed, moreover, that a person who had been "vaccinated" was not infectious to others and that matter from a pustule developed in this way could be used to vaccinate others.

No one paid much attention to this pamphlet, and later that same year Jenner went to London to try to find a patient that he could vaccinate, and so attract the interest of the

London doctors. In three months he could not find a single patient who would let himself be vaccinated.

Then, accidentally, he succeeded. There was a boy in St. Thomas's Hospital in London who was suffering from hip-joint disease. His physician had tried every treatment he could think of, unsuccessfully. Jenner had a quill filled with cowpox lymph that he had kept for three months. The physician decided to inoculate the boy's hip with that—thinking, probably, that he would leave no stone unturned.

Jenner's vaccine did not, of course, cure the hip-joint disease, but some time later they inoculated the boy with smallpox and found to their great satisfaction that he was immune.

Recognition came slowly after that. Jenner became acquainted with the Physician-in-Ordinary to the Prince of Wales, who wanted him to take a house on Grosvenor Square and set up a London practice. "You could make ten thousand pounds a year," he promised.

"But what stock could I add to my little fund of happiness?" Jenner answered him, preferring to return to his country practice in Gloucestershire.

Gradually he was accepted by the medical men in England, was given an audience by the king and queen, and was receiving letters from various parts of England telling of successful vaccinations. One letter from a doctor in Hadleigh, Suffolk, is typical.

I am happy to inform you that in spite of ignorant prejudice, and wilful misrepresentation, this wonderful discovery is spreading far and wide in this country. The first people we vaccinated in Hadleigh were pelted, and drove into their houses, if they

appeared out. We have now persuaded our apothecary to vaccinate the whole town (700 or 800 persons). . . . A physician at Ipswich has taken it up in a very liberal manner.

In America the idea spread faster than it did in England. At first there was some doubt. Some of the lymph that Jenner sent to America was spoiled in transit, and people ridiculed the idea of using matter from a cow to prevent a human disease. One cartoonist drew a picture of some vaccinated children who had the faces of cows. But Thomas Jefferson became interested in Jenner's discovery, and had himself and all his household vaccinated, and he wrote:

> Medicine has never before produced any single improvement of such utility. . . . You have erased from the calendar of human afflictions one of its greatest. Yours is the comfortable reflection that mankind can never forget that you have lived; future nations will know by history only that the loathsome smallpox has existed, and by you been extirpated.

Now in America there was a great rush for the new preventive treatment. Everyone wanted to be vaccinated at once. The process was not always successful. Sometimes the lymph, which was kept in quills, was carelessly prepared and ineffectual. But this was the exception to the general rule. Usually the vaccinations achieved their results: the vaccinated people were immune to smallpox. People in larger and larger numbers were using Jenner's vaccine.

In Canada the Indians of the Five Nations, who inhabited the Eastern woodlands and who had suffered terribly from smallpox, discovered the new process of vaccination with

joy. They held a special council to compose a letter of thanks to Jenner and sent him presents.

The Indians wrote:

> We shall not fail to teach our children to speak the name of Jenner, and to thank the Great Spirit for bestowing upon him so much wisdom and so much benevolence. We send with this a belt, and a string of wampum in token of our acceptance of your precious gift; and we beseech the Great Spirit to take care of you in this world and in the land of the Spirits.

Faster and faster the news of the smallpox vaccine spread round the world, and eager men, women, and children bared their arms for the scratch that would provide an opening for the vaccine. Sometimes Jenner was haunted by the fear that carelessness and the "extreme ignorance of medical men in vaccination" would prevent the world from reaping the full benefit of his discovery, but on the whole he had good news from every quarter where it was tried.

In 1801 the British government had the whole fleet and garrison at Gibraltar vaccinated. And after that all the soldiers and seamen on Sir Ralph Abercrombie's Egyptian expedition were vaccinated also.

In Spain, under the king's orders, a fleet was fitted out to sail to all the Spanish colonies in the Old World and the New so that every subject of the Spanish king might have the boon of vaccination. The ships of this little fleet carried twenty-two children aboard who had been inoculated, to keep up the strain of lymph, since Jenner had found that the lymph need not necessarily be taken direct from the cow. The expedition was gone three years and visited,

among other places, Buenos Aires, Mexico, and the Philippines. In every harbor the vessels were greeted with excitement and hope.

In the town of Palermo in Sicily, where eight thousand people had died of smallpox in 1801, the people formed themselves into a great procession, following their priests to the place where they would be vaccinated.

Soon Jenner's pamphlet had been translated into Chinese; for "in China the smallpox was attended with the most fatal results."

Turks and Armenians were eager for the vaccine, and in Greece, in Salonika alone, one thousand, one hundred and thirty persons were vaccinated in a single year.

Jenner's reputation continued to grow. The empress of Russia sent him a valuable diamond ring, with a laudatory letter, and his friends made him sit for his portrait.

The great Napoleon wrote: "Ah, it is Jenner. I cannot refuse Jenner anything."

Jenner had not wanted to make any capital from his discovery. What he desired most was to follow a quiet career as a country physician. But he must have been pleased when the British government made him a grant of ten thousand pounds (later another twenty thousand pounds was added to this). In characteristic fashion he wanted to use part of this money to fit out a ship which would carry vaccine to India and Ceylon—an undertaking which proved unnecessary, for the governor of Bombay had already applied for sufficient vaccine through Lord Elgin, the British diplomat, who was touring India.

Always, as time passed, there were detractors who said that Jenner had made no discovery, that vaccination amounted to nothing. And always the practice spread and spread—Hindu and Moslem priests in India learned how to prepare and administer the precious lymph, as did Buddhist priests in China and country ministers in the rural districts of England. A great sheaf of letters arrived in Jenner's mail from everywhere.

One of them, from a country parson in England, was typical of all the rest. "A few years ago I was in the habit of burying two or three children every evening in the spring and autumn who had died of smallpox, but now the disease has entirely ceased."

So the village doctor who had written to his "Address to a Robin" and his verses on "Signs of Rain," the young man who had loved to play his flute and his violin, who had chatted with farmhands and listened to the talk of dairymaids, had made his contribution. It is said that there are doctors now who have never seen a case of smallpox, and credit for this fact may be given to Edward Jenner.

Yet when this is said, it must be added that Jenner never truly understood the cause of the disease that he was seeking to prevent, nor did he contribute anything toward its treatment. What he did was to stumble on a preventive for the dreaded sickness and to persuade the public that they had a responsibility for using it. Those who followed him were to pry deeper into the causes, and so to discover principles that would apply to many kinds of virulent disease.

XIII. LOUIS PASTEUR POINTS TO HIS MICROBES

EDWARD JENNER had never heard of a microbe. He had no idea that microbes could cause disease. So he did not know why his vaccinations prevented smallpox. These things were for another man to find out.

In the seventeenth century Anton van Leeuwenhoeck had seen microbes in a drop of water and called them "little beasties," but he had no idea that they had any connection with disease.

It was Louis Pasteur, the nineteenth-century Frenchman, who first realized that bacteria or microbes were responsible for infectious diseases. This was a very great discovery, and one that set scientists to work in many laboratories, trying to isolate the bacteria that carry disease. Their work is not done yet.

Louis Pasteur was not a doctor, and at the beginning of his career he had no special interest in science. He was born in 1822 in the village of Dôle in the Jura Mountains, but his parents moved to Arbois while he was still a little boy. Pasteur's father was a poor tanner, and it is likely that the boy would have spent all his days in the tannery had his father not been more ambitious for him. His son must go to school, he said, and become an educated man.

Louis Pasteur went to school, but reluctantly—his teachers thought him dull. Prodded by his father, he finished school and went on to the Ecole Normale in Paris, where he was miserable and homesick. Afterward he attended lectures at the Sorbonne and somehow or other got a Ph.D. degree.

Only very slowly did he become aware of the scientific world. He had great patience and was attentive to minute details. These qualities made his work with the microscope quite successful. He gained some reputation for his study of crystals, which he watched through his microscope. He discovered that when a light was passed through a solution containing certain crystals it reflected in one way, but when it was passed through a liquid containing other crystals, it reflected in an opposite way, or did not reflect at all. This he explained, resulted from the fact that there were right-

faced and left-faced crystals. The discovery gained him such a reputation that when a new university was established at Lille, Louis Pasteur, the researcher on crystals, was appointed the first dean.

The town of Lille lay in a district where sugar beets were grown for making alcohol. One day the beet-growers came to Pasteur in his office at the university. The alcohol they had been making was of inferior quality, they said. Could he find out what was the matter by scientific study? Pasteur put away the crystals he had been examining and began to look at beet-sugar solutions.

He had an answer for the growers before very long. Beet sugar changes into alcohol by means of fermentation, he told them. That means that certain minute organisms, like little plants, live on beet sugar, grow, and die. When they are not present there is no fermentation, and consequently no alcohol. Heat kills the little organisms. If the beet sugar is heated beyond a certain point, the microbes are destroyed and the process of alcohol-making is unsuccessful.

This discovery of Pasteur's was of very great practical value, and news of his success in improving the process of making alcohol from beet sugar spread throughout France. Soon other industrialists were bringing their problems to him. The brewers of French beer wanted his advice; the wine-producers sought him out when their wine appeared to have lost its flavor. He was consulted about the best way of making vinegar and the best way of ridding silkworms of disease. He received a delegation of sheep-raisers whose flocks were stricken with a fatal disease called anthrax.

In every case Pasteur with his microscope found much the same thing. Bacteria, sometimes rod-shaped under the microscope, sometimes spiral, and at other times tiny round cells, swam under his lens. They moved about singly or in groups by means of long whiplike threads that extended from one end of the cell or from both. The cells appeared to divide and redivide, and this was apparently their way of multiplying. If Pasteur heated the solution in which they appeared, they died, but at a lower temperature they increased at an astonishing rate.

Here, then, was Pasteur's discovery, which was of great practical benefit to the French industrialists: if you wanted to kill bacteria you could do it by heat; if you wanted to encourage them, you must find out the temperature in which they grew best.

And now Pasteur made another discovery. Some of the bacteria were parasites that lived on the others. These were the disease bacteria. To combat them, to make an animal or a person immune to certain diseases, you could inject weakened microbes of the same disease. This was what Pasteur did when he inoculated sheep with anti-anthrax serum.

He had worked for three years before he succeeded in isolating the anthrax germ. Then he found that old cultures of the microbes that had been kept for some time lost their virulence, and when they were injected into sheep, protected them against an inoculation of fresh virulent microbes. This was exactly the principle on which Jenner's vaccination had worked.

The industrialists of France had accepted Pasteur's help

with beet sugar, wine, beer, and silkworm disease very gratefully, but the sheep-raisers were skeptical. Prevent a sheep from being sick by inoculating him with material taken from an animal that was already diseased? This appeared absurd to them.

Pasteur agreed to demonstrate the truth of what he had said. On May 31, 1881, the members of the Melun Agricultural Society brought him sixty sheep on which to experiment, and doctors, veterinarians, and journalists watched eagerly to see the result.

From among the sheep which had been brought to him he took twenty-four that had previously been vaccinated with attenuated cultures of anthrax bacillus and twenty-four unvaccinated sheep. All these he injected with virulent anthrax bacillus. Two days later all the vaccinated sheep were well, while twenty-two of the unvaccinated ones had died, and two more of them were dying. According to one of Pasteur's biographers, "All France burst into an uproar of excitement" at the success of his experiment.

But in spite of his practical successes, a great many people were skeptical about Pasteur's microbes. How do they originate? they asked. Are they there all the time? Are they generated spontaneously?

"Many microbes drop out of the air," Pasteur answered.

Most scientists refused to believe Pasteur when he said this, and he conducted an experiment to prove it to them. He showed them that a solution containing organic matter in a flask would putrefy if it was boiled and left open to the air, but if he used another flask having a narrow neck the

solution boiled in it would remain pure. This, he explained, was because the air will "drop its dusts and the germs that it carries, at the opening of the neck."

"Dusts and germs"—the idea of them fascinated Pasteur: dusts that dropped into his solution from the air, laden with their microbes; microbes that, once they were present in the solution, multiplied, unless other microbes did them battle. His mind was filled with the idea of them, so that cleanliness appeared to him more and more important. His eyesight was not very good, but he had a habit of peering carefully at every instrument he used in the laboratory. At home when he sat down to a meal he examined every plate and cup, every knife, fork, and spoon, and wiped each with his napkin. When he had been invited out to dinner, this practice would sometimes astonish his hostess, but when he saw her look of surprise, he generally told her that he was following regular laboratory procedure.

Pasteur was in the very midst of his explorations and discoveries when he was stricken with a cerebral hemorrhage. French scientists and industrialists alike were shocked at the news of his illness. There was still so much about microbes that they did not understand. And Pasteur was only forty-six.

As if he realized that he could not be spared, Pasteur rallied from his illness. For three months he was away from his laboratory, though he talked often of his experiments and dictated papers about them. Then, paler than he had been before, with a little stiffness in his left arm and side, and a slight limp when he moved about the laboratory, he was back at work again. The leaders of French industry believed

now that the pale man with the stiff arm and leg could find a panacea for every difficulty that beset them.

Pasteur continued with his work, but his labors now were in the service of human beings. His discovery that one set of microbes could battle with another set led naturally to work in human disease. It led first of all to rabies vaccine. When a child was bitten by a dog with rabies, the microbes in the animal's mouth entered the bloodstream of the child, he reasoned. If he could develop a serum that would combat the rabies bacteria, he could conquer the dreaded disease. Certainly there was nothing the matter with the theory.

In 1880 a veterinary had sent Pasteur two rabid dogs Before long he had isolated the microbe that caused the rabies, and stated that healthy dogs could be protected from the bite of rabid dogs by being inoculated with weakened rabies serum.

His serum worked very well with dogs. He had never tried it with a human being. But on July 6, 1885, a woman from Alsace arrived at his laboratory with her boy of nine, Joseph Meister. The boy had been badly bitten by a rabid dog. His doctor, knowing that he could do nothing for him, had sent him to Pasteur.

Had Pasteur the courage to inoculate this boy with his serum? Should he inject the microbes of rabies into the boy's bloodstream? In great agitation he called his laboratory assistants about him. Should he try? Would he be held responsible if the boy died?

Finally, because he knew that the boy would certainly die if he did *not* treat him, he decided to start inoculation. He

planned to begin with a very weak serum and to continue day after day with stronger serum for a month.

While he was treating Joseph Meister, Pasteur could hardly eat or sleep, but went often to sit beside the boy's bed. At last, on August 3, he wrote his son, "Very good news last night of the bitten lad. . . . It will be thirty-one days tomorrow since he was bitten."

And Pasteur went off to the country for a rest. The boy's life had been saved. He was the first to escape death from rabies by the use of the vaccine.

News of the anti-rabies serum spread fast. The czar of Russia sent four men for treatment. They had been bitten by rabid wolves. In America the New York *Herald* took up a subscription to send Pasteur four children who had been attacked by a mad dog. A doctor came with them, together with the mother of the youngest one, a boy of five. Pasteur's treatment saved them all.

By October 1880, Pasteur was ready to make formal announcement of his anti-rabies treatment to the French Academy of Science. The announcement was greeted with great enthusiasm. The Academy voted to erect the Pasteur Institute in Paris, which was to be a center for the distribution of the rabies serum, and a laboratory for the study of infectious diseases.

They had no difficulty in getting funds; two million, five hundred thousand francs were quickly subscribed. Money came pouring in from America, and there were subscriptions from the czar of Russia, from the emperor of Brazil and the sultan of Turkey.

In 1888 Pasteur attended the dedication ceremonies of the Institute, which was to provide all the facilities he could wish for in carrying out the work he had begun.

With meticulous care he had prepared a speech for the occasion. His wife had copied it in her clear, legible handwriting. But when the moment came for reading it, his voice choked and he could not read. It was his son who read the words.

"Our Institute shall be a dispensary for the treatment of hydrophobia, a home of research for the study of infectious diseases, and a center for the teaching of subjects that bear upon microbiology."

Pasteur was not well enough to do much work in his beautifully appointed laboratory. But he went there nearly every day when he was able, to talk with the younger scientists who had come to study diphtheria, typhoid fever, typhus, tuberculosis, and many other diseases. Robert Koch, the German bacteriologist, said, "As soon as the right method was found, discoveries came as easily as ripe apples from the tree."

Not many men have had the satisfaction of seeing their accomplishments so fully realized and appreciated as did Pasteur. He had confirmed and explained the work of Jenner; he had pointed out the connection between microbes and disease; he had started the process of pasteurization. With him modern medicine truly began. To the French people he was a hero greater than Charlemagne, greater even than Napoleon.

On the morning of December 27, 1892, which was

Pasteur's seventieth birthday, the dignitaries of France and representatives of many foreign nations crowded the vast amphitheater of the Sorbonne to do him homage. There were the president of the French Republic, ambassadors and ministers, representatives of French learned societies and of scientific, pharmaceutical, and agricultural bodies of many lands. When Pasteur entered the theater the band burst into martial music, but the old man for whom all this had been arranged came in slowly on the arm of his son, dragging his left foot.

There were speeches that morning by the president of France, by Lord Lister, the great surgeon who had come from England for the occasion, and by others. One wonders how many of them Louis Pasteur heard or remembered.

But he carried home with him afterward a medal that he must have prized. On one side it bore his profile, and on the other the words:

> To Louis Pasteur on His Seventieth Birthday.
> France and Humanity Are Grateful.

Now in the laboratories in many places scientists began to try to track down the microbes that caused disease. "There must be a separate microbe for each separate kind of infectious disease," Robert Koch said. "If you can separate the microbe and develop a serum to combat it, you will have conquered the disease."

XIV. BRAVE DOCTOR, BRAVE PATIENT

SURGERY was slow in its development. In the renowned hospitals of Europe in the early part of the nineteenth century there were only a very few operations which the surgeons dared to perform. They could amputate limbs; they could remove gallstones; they could cut out external tumors. Not even the most distinguished surgeon would cut into the abdomen or the chest. Ailments in those places were not to be interfered with, even by the boldest.

And it was not by a distinguished surgeon working in an important medical center that the first abdominal operation

was performed. It was Ephraim McDowell, a practitioner on the Kentucky frontier, who tried it. He knew that his patient would die if he did *not* operate, and he wanted his patient to live. In December 1809 he removed a large ovarian tumor from Mrs. Jane Crawford—the first such operation that had ever been performed.

The story of that operation reads like a drama. It is vividly told in James Flexner's book, *Doctors on Horseback*. No one knows exactly what words were spoken, but these are the facts of the story.

On the night of December 13, 1809, the heavy brass knocker on the front door of Dr. Ephraim McDowell's house in Danville, Kentucky, rapped sharply. Ephraim McDowell himself opened the door, and a swirl of snow blew in as he looked out into the storm.

"What is it?" he asked the traveler who stood on his door-step.

The stranger, muffled in his furs, looked up at him. "Doctor," he said, "I've just come from the settlements out beyond Boonesboro. Thomas Crawford's wife, Jane, has been taken very sick. Can you go to see her?"

Ephraim McDowell cast a quick look around the comfortable room that lay beyond his hall, at his wife knitting in her rocking chair, at his warm fire. "What's the matter?" he asked.

"I don't know," the stranger answered, "but it's bad. The doctor out there at the settlement can't seem to tell. . . . But it's bad," he said again.

It was more than sixty miles through the woods to the

frontier settlement, but the distance did not seem to the doctor out of the ordinary. Sometimes he rode as much as a hundred miles, over rough trails, to see his patients. Occasionally his work took him away from home for a week at a time.

It did not take him long to get ready. His apprentice saddled the horse, put his medical supplies and some food into the saddlebag, and brought him his musket—for there were wolves along the frontier. Then Ephraim McDowell pulled his coonskin cap down over his ears, turned up the fur collar of his coat, drew on his gloves.

Mrs. McDowell, standing at the open door, watched him ride off through the snowy woods. She noticed, as he disappeared, how lank and tall he was. His feet nearly touched the ground when he sat in the saddle.

The snow along the trail was unbroken for the better part of the way, but here and there he passed a settlement. The settlers waved when they saw him, for he was a familiar figure to them, and they depended on him when trouble came. They knew how skillfully he could probe for bullets and how cleanly he could amputate a limb. They knew that no one could remove gallstones with such success as could this rider in his coonskin cap.

It took McDowell the better part of two days to reach the settlement. There a little inquiring brought him to the Crawfords' log cabin. The storm had cleared, and Mr. Crawford with his six children was waiting for him in the sunny space outside the door.

"I'll go in to see her," McDowell said.

He stopped for a moment inside the door so that his eyes might adjust themselves to the changed light. The sun had been bright on the snow outside; here in the cabin it was half dark—a single candle was flickering. The fire had burned down to coals, and there was only a dim light from the single window with its cover of oiled paper. Then he saw the patient he had come to treat. Jane Crawford was lying on a rough bed of willow branches in the corner.

"I've come to help you," he said, putting out his hand to her.

She tried to answer but was stopped by a paroxysm of pain.

It did not take him long to make his examination.

She had thought that she was with child again, but it had been ten months now.

"It's not pregnancy," Ephraim McDowell told her. "It's a tumor."

He turned away toward the door, and then came back to her bed again. He did not need to tell her that it was serious. Everyone, even the settlers on the frontier, in those days knew that an ovarian tumor was fatal. They were both silent.

Then Ephraim McDowell spoke again. "I think," he said, "that if you were willing to let me try, I might be able to cure you by cutting the tumor out."

There was no answer and no movement from the bed where Jane Crawford lay. McDowell went on talking. He sat down on a stool near her bed, wanting her to follow exactly what he had to say.

"The doctors at Edinburgh, where I studied, all say that such an operation is impossible. But they may be wrong.

And they say that anyone with a tumor such as yours cannot live more than two years." He had risen and was walking back and forth in the little room. "I think I could cut it out," he said at last. "I have spayed animals, and they recovered. This operation would be much like that."

A strange conversation this—the tall, kind physician, and the woman making up her mind.

"Of course I couldn't do it here." He sat down again on the little stool beside her bed. "I'd need my instruments, and some expert assistance. . . . Could you stand the ride to Danville?"

"I'll try," Jane Crawford said.

Early next morning they started. Thomas Crawford could not go with his wife—there was the farm to be taken care of, and the children must be looked after. But a neighbor woman volunteered to go and help in any way she could.

They lifted Jane Crawford to the saddle. Then the neighbor woman and the doctor mounted their horses; Thomas Crawford and the children waved to them; and the trio started on their way through the woods.

They made the journey to Danville in two days, stopping at some cabins to spend the night. On the afternoon of the second day they reached the comfortable house where Ephraim McDowell lived, and his wife met them at the front door and took Mrs. Crawford in to put her to bed.

Ephraim McDowell planned to operate on Christmas Day. That would give Jane Crawford a little time to rest after her journey, McDowell thought. Perhaps, too, the day might bring its blessing to his work.

Meantime, while the patient lay in her comfortable bed, Mrs. McDowell prepared rich broths and nourishing soups to build up her strength, while Ephraim McDowell studied his anatomical charts and made his plans.

Soon the news of what he was about to do spread through the village of Danville. At first the people spoke of their pity for "poor Mrs. Crawford." Then they began to whisper against the doctor. "He's no better than a murderer," they said.

Dr. James McDowell, Ephraim's nephew, who had also been educated at the University of Edinburgh, shared in the general feeling of disapproval. He would have no part in the operation. The woman was very likely to die. The practice which they had built up over the years would be ruined.

The doctor made no comment. His apprentice, young Charles McKinny, could give him what help he needed.

On the morning of Christmas Day the people of Danville were in church when Ephraim McDowell began the operation. The minister was preaching against those who had the pride to think they could take God's decisions into their own hands. Everyone knew he meant McDowell.

But in his house farther up the street Ephraim McDowell had laid out his instruments on a clean linen napkin and, with the help of his apprentice, had carried Mrs. Crawford to the operating table. At the last minute the nephew, James McDowell, changed his mind. He would help, after all.

There were no anesthetics then. Ephraim McDowell gave Mrs. Crawford a large dose of opium, marked the area to be incised with purple ink, and handed the knife to his nephew.

They say that Mrs. Crawford sang hymns while they cut, gripping the edge of the table with her strong hands. From time to time the doctor paused to lean down and speak to her. Then they went on.

Meanwhile, the church service was over, and the people congregated in front of Ephraim McDowell's house. They could hear the sound of Mrs. Crawford's singing, loud at first, then weaker. If Ephraim McDowell killed her it would be the worse for him. His daughter said later that they had thrown a rope across the limb of a tree. If Jane Crawford died they would not wait for the law to take its course.

But Jane Crawford did not die. In "about twenty-five minutes" the great tumor had been removed—it weighed twenty-two and a half pounds! The wound was closed. Jane Crawford was carried, half conscious, back to bed.

The crowd outside McDowell's door dispersed when the news came that Jane Crawford was alive. Perhaps the doctor knew what he was doing after all, the people said.

But to Ephraim McDowell, watching his patient and dressing the wound, the period of anxiety had just begun. For signs of the infection which he had no way of combating might appear at any time. Peritonitis, an infection of the abdominal wall, was what all doctors had believed inevitable when the abdomen was opened, and Lister's method of antiseptic surgery was not yet known to McDowell

But no sign of peritonitis appeared. On the fifth day after the operation, Dr. McDowell, entering her room, found Jane Crawford making the bed. She was not used to lying around, she said.

With dire threats he managed to get her back beneath the blankets, and to keep her there for twenty-five days. Then she mounted her horse and rode back to her settlement—to her husband and her children and to the cabin that needed her care. It is said that she lived to be seventy-nine years old.

Some time later McDowell performed another successful operation of the same kind, and after that he wrote an account of it and sent one copy to his old teacher, John Bell, in Edinburgh, and another to Philadelphia, where it was published in *The Eclectic Reportory* in 1817. Doctors in both Europe and America were very skeptical at first, but gradually in Glasgow and London they ventured to try the operation. After that physicians everywhere realized that abdominal operations were possible.

It seems that both Jane Crawford and Ephraim McDowell should share equally in the credit for what they did. Perhaps it is only natural that the feat should have been performed on the Kentucky frontier, where men and women were accustomed to courage. Every time an appendix is removed now, or for any other reason a doctor penetrates the abdominal cavity, he does it with confidence because of that first abdominal operation that Ephraim McDowell performed on Jane Crawford back in 1809.

XV. WHO DISCOVERED ANESTHESIA?

TO FIND a substance that would bring relief from pain —that was an old, old dream. The doctors of the school at Salerno had concocted such a substance, but it was forgotten again as the years passed. In the eighteenth century Humphry Davy, the English chemist, had made a gas of which he observed, "As nitrous oxide . . . seems capable of destroying physical pain, it may probably be used with

advantage in surgical operations." But Humphry Davy did nothing further about this.

Henry Hill Hickman, a young English doctor, had experimented with carbon dioxide, inhaling it himself, and watching how small animals appeared insensible to pain when he administered it to them.

But no one would listen to Henry Hill Hickman. So it was not until the nineteenth century that a true anesthetic was made. And who made it first is a question that has never been satisfactorily answered. But certainly it was in America that it was discovered.

Many people in the United States were interested in nitrous oxide then, but they were not doctors and surgeons. They were showmen.

For towns were springing up in the newly settled West, and people on the frontier wanted entertainment. Little groups of men gave their shows in hired halls or on street corners, and passed round their hats for coins. One of their most popular acts was to show the crowds how queerly people behaved when they inhaled "laughing gas," as they called nitrous oxide.

One of the laughing-gas shows was given by a man who advertised himself as "Dr. Coult [sic], of London, New York, and Calcutta." He was raising money to finance the patents on what we now know as the Colt revolver.

Colt toured the Massachusetts towns, carrying his laughing-gas apparatus with him through the streets in a pushcart. He said that he made as much as ten dollars a day.

Ten years later he was in Cincinnati. There he hired a hall and engaged six Indians to sit on the stage. He thought he would give the laughing gas to the Indians first, and that this would increase the confidence of the audience, who would then take it themselves. To his consternation, however, the six Indians, instead of being exhilarated, all went to sleep. In desperation he gave his gas to a blacksmith, who was so much stimulated that he chased the awakened Indians around the stage. A merry evening ensued; the people were soon breathing gas, laughing, shouting, and rolling in the aisles.

But laughing-gas shows were not confined to the North and West in the United States. Soon they were also touring the South. In December 1841 one of them visited the sleepy Southern town of Jefferson, Georgia.

A graceful young man with curly hair was the village physician in Jefferson. He liked to dance and to wear flowered vests, and he was very popular with the young people. His name was Crawford W. Long.

The day after the laughing-gas show had come to Jefferson, a number of Dr. Long's young friends gathered in his office, where the physician, who also acted as a druggist, kept rows of bottles and jars on his shelves.

"Can't you make us some laughing gas?" they asked him.

"I haven't the apparatus for making or preserving it," Long told his visitors. "But I have a medicine called sulphuric ether which will do as well. I sometimes give a few drops to nervous patients."

Thereupon Dr. Long took down a bottle and poured out a few drops on a folded napkin. "I've often tried inhaling it myself," he said.

At first the young visitors were afraid to try it, but finally one of them said he had inhaled it before, when he was in school.

"Try it again," Dr. Long said, holding the folded napkin under the young man's nose. Then Dr. Long inhaled some of the gas himself, and after that everybody was willing to try. The experiment was a great success.

The young men came often to Dr. Long's office to inhale his gas, and soon they were bringing young ladies with them. Before long ether parties were being held all through the county, and in other parts of Georgia as well.

People called these affairs "ether frolics," and they were extremely popular. Boys and girls who had breathed the gas threw themselves about hilariously, knocking against furniture, often falling down, bruising themselves, and scraping shins and elbows. The strange thing was that though the cuts and bruises were often considerable, the participants in the ether frolics never complained of them—indeed, they didn't even seem to notice that they had hurt themselves.

The ether prevents their feeling pain, Crawford Long thought.

One day a youth named James Venable came to Long's office with two little tumors on the back of his neck. He wanted them removed but he was afraid to have Long operate on them.

"If you would breathe some ether, you would probably not

feel it much," Long said. And, fearful, James Venable agreed to try.

Several young men stood at the back of the room to watch the operation, and the principal of the local academy was asked to come, thus lending dignity to the occasion.

Long poured ether on a folded towel and held it to the frightened Venable's mouth and nose. From time to time he pricked him with a pin to see whether the ether was taking effect. After a few minutes Venable's taut muscles relaxed, and he appeared to sleep. Then Long picked up his knife and removed the tumor. Now, slowly, Venable came to, and said he had felt nothing more than a slight scratch on his neck.

Afterward the operation was recorded in Crawford Long's ledger as follows:

James Venable, 1842
Ether, and excising tumor, $2.00

It is a question why Crawford Long did not report this first surgery under ether to the medical journals at once. Whether he was waiting to confirm what he had done with more cases, or whether his time was too taken up with the details of his practice, or with parties, is not known. Perhaps he did not realize the importance of what he had done.

Whatever the reason, it was a shock to him to read in a medical journal in 1846 that William T. G. Morton in Boston had administered a gas to a patient undergoing a surgical operation that made him insensible to pain. The article praised Morton's achievement highly. Who was this William

T. G. Morton who had done exactly what he had done, and was now receiving such acclaim? The credit should have come to Long himself.

The bitterness of what he regarded as neglect grew upon Long as the years passed. When he marched off to the Civil War he carried a glass jar in which he had placed a roll of papers—"my proofs of the discovery of anaesthesia." When he returned from the war again the papers were placed in a trunk in his attic, and no one in his family ever dared to speak of them; the mention of them distressed him too much.

Meantime, in the North, the discovery of the drug that rendered men unconscious of pain was making a great stir. Almost everyone claimed that Morton had made the discovery, though there were some who were not so sure. These said that Horace Wells, a dentist, should be given the credit, and others spoke of Charles T. Jackson, a chemist.

Morton had begun his career by being a dentist. Only after his marriage did he begin to study medicine. But physicians did a great deal of dental work then, anyway. Their usual method of curing an aching tooth was to extract it, but since tooth-pulling was a painful and difficult thing to do, they very often simply wrenched off the crown, leaving the infected roots to fester. They knew it would be better to pull out the roots, but that was far too painful.

Horace Wells was Morton's partner in dentistry. And it was Horace Wells who one day saw an exhibition of laughing gas. Excited, he went home, and next day allowed a friend who was a dental student to pull out one of his teeth, roots and all, after he had inhaled the gas.

"I could not feel so much as the prick of a pin," he said later. "It is the greatest discovery of the age."

He now persuaded fifteen patients, one by one, to let him pull their teeth after he had administered gas. Then he felt that he was ready to give a demonstration at the Massachusetts General Hospital. Dr. John C. Warren was chief surgeon there.

For some reason, perhaps because he did not put enough nitrous oxide on the napkin that he held under the patient's nose, things went wrong at the demonstration. The patient shrieked and jumped up, the students laughed, and the sensitive Wells, crushed by his failure, disappeared through the door.

That was in 1845, and though Wells had been the first man to use nitrous oxide in dentistry, he received no credit for it. He brooded over his failure, finally gave up his practice, drank heavily, and at last committed suicide.

But Morton, his former partner, had known of Wells's experiments, and though the demonstration at the Massachusetts General Hospital had been unsuccessful, the idea of freeing people from pain stayed with him. If he could find a way of doing that, patients would flock to his door; his fortune would be made!

Why had Wells been unsuccessful? Morton wondered. Was it because the gas had not been properly administered? Would the results be better if the gas was given from a vessel with a long tube, so that the patient's breath would not mix with the gas? He went to his friend Charles T. Jackson to see if he could borrow such a vessel.

Charles Jackson was a brilliant chemist, and an eccentric man. Several years before, he had crossed the Atlantic Ocean on a ship with Samuel F. B. Morse, and later, when Morse invented the telegraph, Jackson insisted that the idea had been his. It was known around Boston that he had laid claim to many ideas that were not his own. Since Morton knew of Jackson's reputation he tried to keep his idea secret. Would Jackson lend him a piece of apparatus for experiment? was all he asked.

It was not long before Jackson learned what Morton was about, however.

"It might be better to try sulphuric ether rather than laughing gas," he said.

So Morton took the apparatus and began his experiments with ether. Early in 1846 he had perfected the procedure and felt that he was on the verge of making his fortune.

He wrote to Dr. Warren, the same doctor who had given Wells his chance to try his nitrous oxide gas at Massachusetts General. In his letter Morton said that he had a new preparation that would create insensibility for surgical operations. In about ten days he had an answer to his letter, asking him "to be present on Friday morning at ten o'clock to administer to a patient who is then to be operated upon, the preparation which you have invented to diminish the sensibility to pain."

Now Morton became very nervous. He knew that the ether did not always act the same way on all patients. Suppose the patient became intoxicated with it, suppose he tried to

struggle and fight with the doctors? Suppose they laughed at him as they had laughed at Wells?

He rose very early on the morning of the demonstration, and went to the shop of an instrument-maker named Frost. He had thought of a slight modification of the instrument with which he planned to administer the anesthetic. Frost was reluctant to make a new instrument that morning. There was not much time before ten o'clock, he said. But Morton forced him to work, told him to hurry. It was nearly ten o'clock when the instrument was at last ready.

At ten minutes after ten Morton, followed by the breathless Frost, carrying the instrument, appeared at the door of the operating theater of the Massachusetts General Hospital.

Inside the operating theater the patient had lain for a full ten minutes. Most of the great surgeons of Boston occupied the front row of the circle of seats, waiting. Dr. Warren stood beside the operating table, his watch with its heavy gold chain in his hand. He had just announced, "As Dr. Morton has not arrived, I presume he is otherwise engaged," when Morton, with Frost behind him, burst into the room.

Dr. Morton lost no time in starting to administer the drug. The patient, a sturdy young man, shuddered a little, and fell into a deep sleep.

"Your patient is ready," Morton said to Dr. Warren.

Dr. Warren took up his instrument. The operation was for the removal of a large tumor which extended along the jaw to the mouth. The patient did not stir as the knife cut into his flesh. The great surgeons who were watching saw Dr.

Warren remove the tumor and sew up the wound. Then they saw the patient stir as consciousness slowly returned.

"Did you feel any pain?" Dr. Warren asked him.

"No, it didn't hurt at all," the patient said.

Now Morton felt that he had really achieved success. He made arrangements with the Massachusetts General Hospital to sell them his preparation for use in all their surgical operations. He called it "Letheon," keeping its composition a secret. He did not want anyone to know that it was simply ether, which could be found in any doctor's cabinet. He disguised its odor by mixing it with some aromatic oils. He invested all his money in making more apparatus, and dreamed of selling "Letheon" to hospitals everywhere.

But Morton did not make the fortune of which he had dreamed. Before very long the medical staff at the Massachusetts General Hospital refused to buy his preparation unless they knew what was in it.

And soon Charles T. Jackson was saying that the idea of administering ether was his idea, not Morton's, while from the Georgia Medical Society came indignant protests that no Northerner had made the discovery. Had not Crawford Long operated on James Venable's neck, painlessly, back in 1842?

William T. G. Morton, who had dreamed of riches, died at last in poverty, and Charles T. Jackson ended his days in an insane asylum.

So a number of men claimed that they were first to produce anesthesia. But in the end it does not matter to whom the credit is given. Oliver Wendell Holmes, the poet and

physician, first suggested the word "anesthesia." He wrote to Morton, November 21, 1846:

> Everybody wants to have a hand in the great discovery. All I will do is to give you a hint or two as to names. The state should I think be called anaesthesia. This signifies insensibility more particularly . . . to objects of touch. . . I would have a name pretty soon, and consult some accomplished scholar . . . before fixing upon the terms which will be repeated by the tongues of every civilized race of mankind.

The cruel days of consciousness under surgery were over.

XVI. LISTER AND HIS "ANTISEPTIC METHOD"

WHILE anesthetics were being developed in America, Joseph Lister was making another great contribution across the ocean, in Scotland. There he was working out what people called his "antiseptic method." This method had its roots in Pasteur's idea of microbes.

Pasteur's concept that microbes could drop into a solution from the air was to have results far beyond any that he could anticipate. No one, including Pasteur himself, realized the great changes that it would bring to surgery.

Joseph Lister, walking down the High Street in Edinburgh in the mid-nineteenth century, had never even heard of Louis Pasteur. Lister had come to Edinburgh to study surgery in the old-fashioned way under Joseph Syme, the greatest surgeon of his time. So enthusiastic and full of zeal was the young student of surgery that he hardly noticed the tweed-coated men and the ladies with their crinolines who crowded the streets around him. He himself was tall then, and strongly built. He wore side whiskers, and had a shaved chin and upper lip, according to the fashion of the day. His tall silk hat was firmly set on his head; the inside of his hat was a convenient place for carrying his stethoscope.

In the first part of the nineteenth century the new Surgical Hospital was opened. The seventy-two patients under Dr. Syme's care were distributed in six wards. Water for the wards was carried in buckets, and heat was supplied by open fires, while lamps and candles gave illumination in the dark of evening and in the early mornings.

One of Dr. Syme's assistants has told how the famous surgeon worked. His description is quoted in *Lord Lister, His Life and Doctrine*, by Douglas Guthrie, as follows:

> Driving down in his big yellow chariot, with footman, hammer-cloth and C-springs, with two big, rather stately and slow white and grey horses, he used to expect his house surgeon to meet him at the door and move upstairs with him to his little room where he at once took up his post with his back to the fire and his hands under the flaps of his swallow-tail coat. In this little room he generally had a small *levee* of assistants, old friends, practitioners waiting to arrange a consultation, old pupils home on leave; and before this select class he examined each new interesting case that could walk in. The new cases had been collected, sifted and arranged by the dresser in a little room on the stair, irreverently known as the "trap," and Mr. Syme then and there made his diagnoses, which to us young ones seemed magical and intuitional, with certainly the minimum of examination or discussion. . . . Then if it was lecture day, there would be a tremendous rush of feet on the stairs as students rushed to get the nearest seats in the large operating theater where the lecture was given.

Here the operating table, a wide board padded with leather, was set in the center of the stage; Syme occupied a cushioned chair called the "chair of clinical surgery"; the house surgeon stood a little nearer the door; the instrument

clerk presided at his well-stocked table under the window.

Syme's assistant goes on to describe how the surgeon worked.

> He comes in, sits down with a little, a very little bob of a bow, rubs his trouser legs with both hands open, and signs for the first case. The four dressers on duty, and in aprons, march in (if possible in step), carrying a rude wicker basket in which covered by a rough red blanket, the patient peers up at the great amphitheater crammed with faces. A brief description . . . and then the little, neat, round-shouldered man takes his knife and begins.

After the operations were over, the patients were returned to the wards. There were two dour Scotch women who acted as nurses in the wards in the daytime. At night there were no nurses, but some porters who cleaned the wards and did what they could for the sick. Lister often sat up all night with the post-operative patients.

Now, in 1853, Joseph Lister came to work under the renowned Dr. Syme in Edinburgh. And in 1860, after completing his training, he was appointed Professor of Surgery at the University of Glasgow. He regretted leaving Syme and his friends in Edinburgh, but turned toward the old shipbuilding city on the Clyde with eagerness. Here he was to be the one responsible, the one to make the plans and give the directions. He was then thirty-three years old, full of energy and ambition.

His wards in Glasgow were rather dismal ones. One of the first things he did on his arrival was to put in a large order for more soap and towels, an act over which the Board of Governors grumbled, fearing additional expense. But soap

and water were not enough to drive out the menace of infection that hung over Glasgow's surgical wards.

For in Glasgow, as in all the hospitals in those days, patients almost never recovered from operations without complications, and a surgeon hardly ever saw a wound heal cleanly, without suppuration. At least a third of all the patients who had been operated on died later. For a long time doctors had spoken of "laudable pus," and thought that pus was necessary to the healing of wounds. Lister was already beginning to question this idea.

What is the use of operating on a patient if he is to die of infection? he began to wonder, as he stood in the wards, watching the feverish patients with their swelling, painful wounds. Blood poisoning was common among them, and erysipelas, an infection of the skin sometimes called St. Anthony's fire, spread with epidemic violence, causing many deaths. Pyemia appeared after many operations, forming fatal abscesses in various parts of the body, and tetanus, or muscular spasm, for which there was no known cure, frequently appeared. Hospital gangrene, the most feared of all infections, was dreaded by both patients and doctors. It was customary to lump all these infections together, to speak of "hospitalism"—a dreaded and mysterious condition.

Some surgeons thought that the bricks and stones of the actual hospital buildings were the source of difficulty and urged that the buildings be torn down. But Lister did not believe that the difficulty lay in the buildings themselves. He began to spend a great deal of time in the laboratory, studying infections under his microscope.

One of the things that Lister noticed was connected with the healing of fractures. He observed that if a bone was broken it could generally be set and would heal without difficulty, whereas if the fracture was a compound one, so that the bone protruded through the flesh, in nine cases out of ten there was infection. Why was this? Was there something in the air that entered into the wound when the skin was broken?

One day in 1865 he talked to his friend Dr. Thomas Anderson of this perplexing thing, as they walked home from Glasgow Infirmary together.

"Is there something in the air that causes the wound to putrefy?" he asked.

"There is a Frenchman, Louis Pasteur, who has done some interesting work on putrefaction," Anderson said. "He claims that it is caused by the growth of microscopic organisms. I can lend you his book."

So Lister borrowed Pasteur's book, and read it, and found the reason for the growth of infection in wounds.

Pasteur had succeeded in checking the growth of organisms by high heat, but Lister could not apply sufficient heat to kill microbes in living patients. Could he kill the organisms by means of chemicals, perhaps?

He tried various chemicals unsuccessfully. Then he read somewhere that carbolic acid had been used in treating sewage in the city of Carlisle. Would carbolic acid prevent the growth of the organisms?

He sent for a sample of it It was a sticky, evil-smelling fluid, which some people called German Creosote. He found

that it was insoluble in water, but it dissolved easily in oil. Finally, after much investigation, he found a firm in Manchester which manufactured a more refined carbolic acid that was soluble in water. He made a solution of one part carbolic acid to twenty parts of water. He thought that this might destroy the microbes without destroying the delicate human tissues.

In March, 1865, a case of compound fracture was brought into the hospital. A boy named James Greenless had been run over by a dray in the Glasgow street. His leg had been broken so that the bone protruded through the flesh, making a wound about an inch long and three-quarters of an inch wide. Lister set the bone, dressed the wound with a piece of calico dipped in undiluted carbolic acid, and bound it up. Nervously he waited to see what would happen. When at last he uncovered the wound he found that a scab had formed and that it was healing in a healthy way. But it was a little red and sore around the edges. He thought that the carbolic acid had been too strong.

"One case is not enough to prove anything," Lister said to himself. "I must try it with others."

So he waited. Between August 12, 1865, and April 1, 1867, eleven cases of compound fracture were brought to the hospital. Of these, two died: one man who had been kicked by a horse developed hospital gangrene while Lister was on vacation; the other, a quarryman who had had a stone roll on him, died of a hemorrhage. The other nine all walked out of the hospital completely well.

"Those nine cases are proof," Lister said to himself. And

he was proud, because in nine months in the hospital there was not a single case of pyemia, erysipelas, or hospital gangrene in his ward, though there were many in the other wards of the hospital.

In March, 1867, he published the first installment of the history of the eleven cases of compound fracture in *The Lancet,* the journal of the British Medical Association. But the English doctors thought little of the idea; they did not understand that Lister had made a great new discovery. In fact, the leading surgeons in Glasgow, Edinburgh, London, and Dublin derided the use of antiseptics. The surgeons in America and on the continent of Europe were willing to grant that there might be something in his idea. Professor Thiersch of Leipzig, Germany, wrote him enthusiastically that after he had tried the new method for twelve months, hospital gangrene had disappeared from his clinic.

Lister heard the clamor for and against his antiseptic method but took very little part in the argument. The idea of antisepsis that he had developed from Pasteur's conception of microbes needed further application in surgery.

Bandages and dressings in Lister's hospital, and in the other hospitals of the time, were made of worn-out sheets, towels, and tablecloths donated by benevolent patrons. No one took the trouble to cut off the embroidered monograms that decorated them, and the laundering of them was indifferently attended to. Lister, going himself to a drygoods shop to investigate materials, found cheap gauze that could be bought in large quantities, sterilized once, and thrown away.

After a time, to avoid the difficulty caused by carbolic-acid burns, he began using "lac plaster." This was a mixture of gutta-percha dissolved in benzine. After he had smeared it on the wound, he covered the area with a piece of calico dipped in a solution of crystallized carbolic acid and shellac. The solution passed through the gutta-percha and made the area beneath it sterile, without injuring the tissue.

"Keep the wounds clean," he kept saying to his students. "Sterilize them with carbolic acid or some other antiseptic, and keep them clean."

Frock-coated surgeons, working in the hospitals, were accustomed to wear little sheafs of silk threads knotted in their buttonholes, for use when they needed to tie an artery or to suture a wound. They simply pulled one of these threads out of their buttonholes and used it. Often the area around the stitch was infected, and Lister, noticing this, had the threads soaked in carbolic acid before they were used. Later he experimented with threads, or ligatures, as they were called, made of catgut, which was absorbed in the tissues and did not need to be removed.

"Surgery is becoming an altogether different thing," Lister wrote enthusiastically to his father.

But even the best hospitals in those days were dismal places. The floor of the operating room was covered with sawdust. The surgeons never thought of removing their dusty coats. One day, watching the motes of dust in a sunbeam, Lister had the idea that the whole air of the hospital might be filled with microbes that could drop into an open wound. If the surface of the wound, and the air around both surgeon

and patient, could be saturated with carbolic spray, he thought, there might be less danger of infection.

So he began to use a carbolic spray, which one of his assistants pumped continually, surrounding him with an antiseptic cloud while he operated. It was hard work to keep the spray going. One day the operator fainted with exhaustion before Lister had finished. Then a larger spray was used, which was set on a tripod and operated with a long pump handle. People used to see Lister, driving to see his patients in a brougham, with the long handle of his spray sticking out of the carriage window.

Carbolic acid was inhaled by both surgeon and patient when the spray was used, and sometimes this resulted in carbolic poisoning. Still, Lister continued to use it for seventeen years, until 1887. After that he decided it was not necessary.

Gradually the protests against Lister's antiseptic method died down. In 1869 he was invited to come back to Edinburgh, to take the chair that old Professor Syme had held until his death. In 1877 he was invited to be chief surgeon at King's College in London.

He was spoken of now as the greatest surgeon in Scotland, and later as the greatest surgeon in London. But he continued to go about his wards, carrying the dressings himself, pausing to speak with his patients, adjusting their pillows himself, saying, "Now are you quite comfortable?" And all the while his spirits mounted as he took the dressings from their wounds and saw that these were healing as he intended.

One day he found one of his patients, a little girl, crying,

though her wound seemed to be healing well. On inquiry he discovered that the nurse had taken her doll away from her.

"There was a hole in it, and the sawdust came out and got into the bed," the nurse explained.

"I think I could heal your doll's wound," Lister said to the child gently. And with his surgical needle he sewed up the hole, and returned the doll to its small owner.

So the years passed. Queen Victoria called him to Balmoral Castle to treat an abscess by his antiseptic method, and the court physician operated the spray for him. It was for the queen that Lister improvised a drainage tube made of a piece of rubber tubing cut from the spray. A French physician, Chassaignac, had already made a tube of this kind, but Lister did not know of it. Afterward the queen tried to get his support in having an anti-vivisection bill passed, but Lister refused, saying that if animals were properly anesthetized, the study of them might save many lives and much suffering.

What Lister said or did not say was of importance now. People were beginning to appreciate what he had done. He took a vacation in Europe, and it turned into a kind of triumphal tour. And at home honors were heaped upon him. In 1883 he was created baronet; in 1895 he became president of the Royal Society; in 1897 he was elevated to the peerage, as Lord Lister; in 1902, on the coronation of Edward VII, he was awarded the Order of Merit; in 1912, on his death, a great service was held for him in Westminster Abbey.

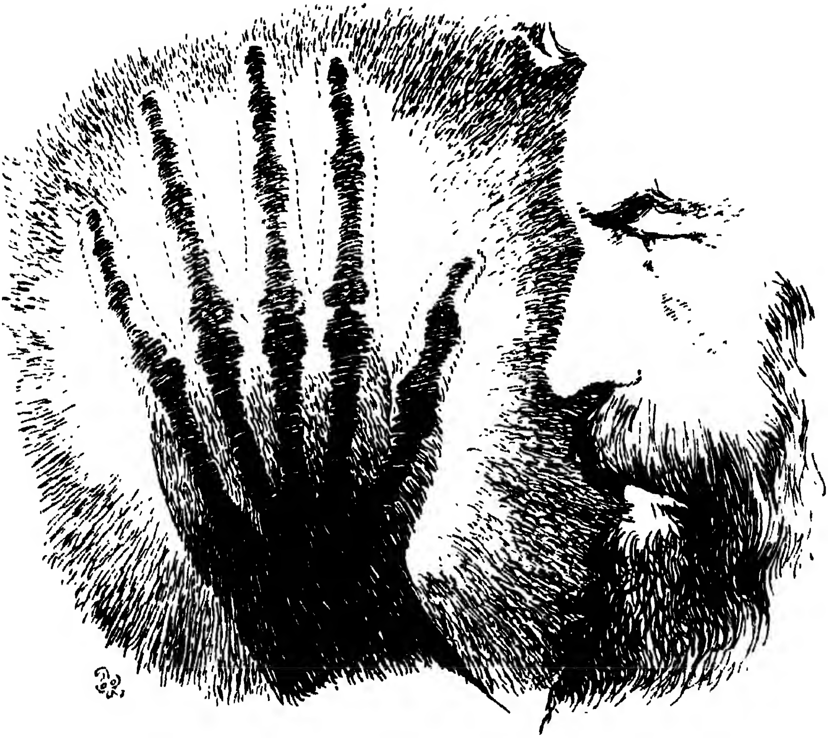
"Who ever heard of a doctor receiving all these honors?"

Dr. William Osler, of Johns Hopkins Hospital in Baltimore, said later.

But what his friends remembered of Lister was not the grandeur and the honors but rather the man himself. "No man I have ever known has left his impress on me as Lister has done," one of his colleagues wrote. He went on to describe the great surgeon for those who did not know him.

> His hands were rough as were those of all his dressers, from frequent immersion in carbolic lotion. He wore a black frock coat and waistcoat of the Victorian type, an upright collar with turned-down points, and a narrow black necktie tied in a bowknot. I never saw him wearing any other hat than the chimneypot silk hat of the period. He was invariably courteous and polite.

Such was the impression that Lister made on his colleagues. But the impression that he made on the practice of surgery was infinitely greater than this, for from his work stemmed all the practices that are part of modern surgical procedure: the clean hospital, the sterile instruments, the gauze bandages and swabs, the uniformed surgeon and nurses, the rubber gloves. Lister did not initiate all these, but he pointed the way toward them.



XVII. "ON THE DISCOVERY OF A NEW KIND OF RAY"

ON THE evening of January 23, 1895, Wilhelm Konrad Roentgen stood before the members of the Physical Medical Society of Würzburg, Germany, ready to report on a discovery he had made. His colleagues knew him as a quiet, modest man, not given to extravagant claims. They could count on him to have checked and proved every step of his investigations.

As he stood before them, his pale, handsome face framed with thick, dark hair, and a curling beard, there was an attitude of intense interest among the learned members of the society. Some of them had read the paper that Roentgen had sent the secretary only two weeks before. It bore the title: "On the Discovery of a New Kind of Ray." What was this ray? How had he found it?

"I was working in my laboratory late in the afternoon of November eighth," he began. "It was already dark. I was experimenting with a Crookes tube."

He paused a moment, as if he were remembering exactly how that Crookes tube was constructed—the gas-filled cylinder of glass equipped with anode and cathode at either end.

"I had covered it with heavy black cloth," he went on. "There were some crystals of platino cyanide on the table. When the electricity passed through the tube, the crystals glowed. The tube was completely covered with black cloth. No light rays could have come through it. Yet the crystals glowed. Some rays other than light rays must have caused the glowing." He seemed as mystified at his discovery as did any of his listeners.

Then he went on to explain that he had tried placing various opaque objects before a screen in the path of the mysterious rays, and that the rays pierced a great many substances such as wood, or flesh, or cloth, but that they were stopped by substances of greater density, such as metal or stone.

"I placed my hand before a screen put in the path of the rays," Roentgen continued. "I could see the outline of the bones framed by the flesh. Afterward I took a photographic

plate, and putting it in the place of the screen, made a photograph of the hand with the bones clearly outlined. Here is the photograph."

The members of the Physical Medical Society stirred and whispered together. To look through the flesh of a hand and see the bones hidden beneath it—this was a new thing. They passed the photograph from hand to hand.

Roentgen had brought his equipment with him. He would repeat his experiment for them if they wished. Was there any one of the members who would like his hand to be photographed in this way?

Albrecht von Kölliker, the eminent anatomist, said he would try. It might take some time, Roentgen warned him. The members settled down to wait.

After a while the photograph was ready. Dr. von Kölliker's hand was clearly shown on the dark plate. The flesh that the rays had penetrated looked like the shadow of a hand. The bones and joints were clearly indicated.

The members of the Würzburg Physical Medical Society were greatly stirred. What would Roentgen call these new rays he had discovered? they asked.

"I do not know what the rays are," Roentgen answered modestly. "I have thought to call them 'X rays,' X being the unknown quantity."

But some of the members wanted to name them Roentgen rays, after their discoverer, and there are people who use this name even today.

The discovery of Roentgen's new rays soon made a stir in

the world outside Würzburg. In April 1895 the *Journal of the American Medical Association* announced:

> The surgeons of Vienna and Berlin believe that the Roentgen photograph is destined to render inestimable service to surgery. . . . Half an hour is the shortest exposure possible and most require an hour. The electric apparatus required is so expensive, $100 and upward, that few surgeons can use it yet in their private practice.

The *Journal of the American Medical Association* was, however, too cautious in its claims. The practice of using X rays took hold very rapidly. Only two years after Roentgen's discovery X rays were being used to locate bullets embedded in flesh or to prove the presence of suspected fractures. The surgeons in the Greek-Turkish War used them in 1897, and in the Spanish-American War of 1898 they were no longer a novelty. Hospitals in many places were buying the equipment that the American Medical Association thought so expensive, and dentists were starting to investigate the condition of infected teeth by means of them.

To be able to look through the flesh and see what was going on inside the human body—it was an idea that appealed to the imagination of all sorts of people outside the medical profession.

Who knew what the scientists might be doing next? they asked. Would they look through the skull and read a man's thoughts? they wondered. This idea of being able to penetrate cloth, and photograph what lay beneath, was dangerous. In London a clothing manufacturer began to advertise

"X-ray-proof clothing," while in the New Jersey legislature a bill was introduced to forbid the use of X rays in opera glasses. One reporter announced that a Columbia University professor had found a way of imprinting facts on the brains of students by means of X rays—an efficient way of teaching, he claimed. And there were some who feared the mysterious force, thinking it might destroy cities or work other havoc.

The worldwide sensation that the new rays were making had very little influence on Wilhelm Konrad Roentgen. He worked on, perfecting his invention and experimenting with it. Gradually the importance of what he had done spread through the scientific world. He was invited to Potsdam to dine with the Emperor Wilhelm—an ordeal, no doubt, for the modest professor from Würzburg. The title of "Excellency" was given him, and streets were named for him. He was given the Order of the Royal Crown, one of the greatest honors that Germany could bestow, and he was made a baron by Prince Ludwig of Bavaria. In America, Columbia University gave him a medal, and in England the Royal Society gave him another.

It never occurred to Roentgen to try to profit by his discovery. If he had patented his X-ray machine he might perhaps have made a fortune, but he never thought of doing this. He had made a discovery—he believed what he had found would help mankind. He was happy to give them what he had discovered. In 1905 the Nobel Prize for Physics was awarded to him. The prize money was the only material benefit the discovery of the X ray brought him.

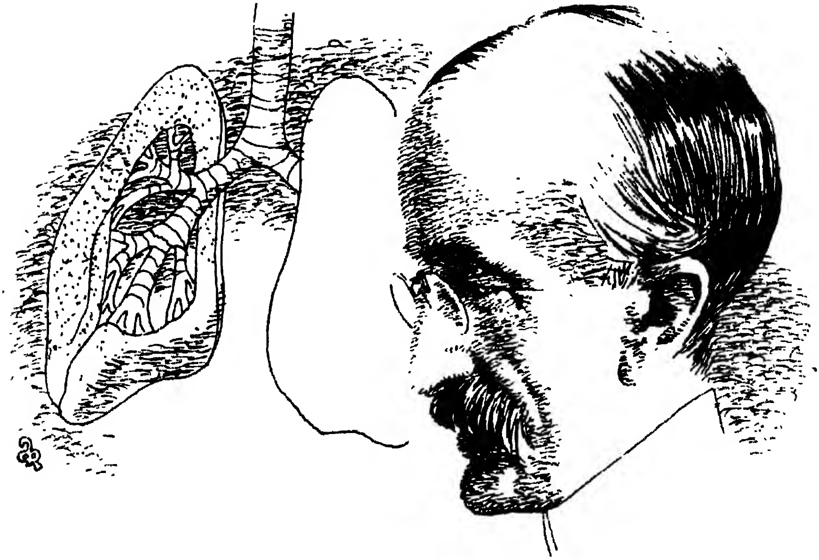
The X-ray tubes that were manufactured in greater and greater numbers were not very different from the tube with which Roentgen had experimented back in 1895. They were glass containers from which the air had been almost completely exhausted. Into their walls two electrodes, anode and cathode, were sealed. A piece of Tungsten, platinum, or other substance was placed in the tube, and when the current was turned on, the metal gave off the X rays. By experiment it was found that rays of varying amounts of penetrating ability could be produced, depending on the amount of air in the tube and on the strength of the current.

At first the X-ray machines were used only for locating bullets or fractured bones. But it was later found that they could also be used in making diagnoses of heart, lungs, intestines, and other organs. They were precise instruments for making diagnoses, as useful as Sanctorius's fever thermometer, or Auenbrugger's percussion, or Laënnec's stethoscope: they enabled the physician to see conditions that would otherwise be hidden inside the human body.

As time passed many scientists studied the X rays that Roentgen had produced. They found that these same rays were given off by radium, and that they were capable of destroying living tissue. Severe burns could be produced when they were applied to human flesh without caution. However, carefully controlled, they could be used to destroy malignant growths in the human body; and radiotherapy, as it was called, took its place as a powerful agent in the treatment of disease.

"The new kind of rays" that Wilhelm Konrad Roentgen had discovered were depended on by doctors everywhere both for diagnosis and for treatment.

But meantime, while doctors were marveling at Roentgen's discovery, and while surgeons were performing more and more brilliant operations with the aid of antisepsis and anesthetics, scientists in many laboratories were continuing their search for the bacteria of disease which Pasteur had started. The German, Robert Koch, had succeeded in isolating the bacillus of tuberculosis. Everyone applauded this great achievement. But no one had succeeded in finding a way to combat the bacillus. That was the problem that baffled Edward Livingston Trudeau, who was himself a victim of the dreaded disease.



XVIII. CAN WE ERADICATE TUBERCULOSIS?

CAN we eradicate tuberculosis? Edward Livingston Trudeau spent most of his life trying unsuccessfully to find a way to cure or prevent it. But though he did not succeed, he made a good start in the right direction.

He began his work in what would seem a rather strange place for scientific research. It was at Paul Smith's in the Adirondacks, where he went in despair in 1873, thinking that he was about to die.

A great many men went from New York to Paul Smith's in the 1870s for hunting and fishing. In those days it seemed very remote, and the journey to it was a tedious one. They took the train to Saratoga, rested overnight, climbed aboard

another train to Whitehall, took a boat through Lake Champlain to Plattsburg, a little branch iron-ore road to Ausable Forks, and then finally drove into camp forty-two miles over a rough road made of logs in an old-fashioned, two-horse stage wagon.

Trudeau had been to Paul Smith's often, for he loved hunting and fishing, and he loved living in the woods. When he discovered that he had "consumption," he wanted the peace and quiet of the great woods, and the clear, pine-scented air. His health improved greatly when he got there; he was soon eating and sleeping again, and his fever began to disappear.

Trudeau had probably contracted tuberculosis when at seventeen he had nursed his brother, who had the disease. In those days the doctors believed that every window of the sickroom must be shut tight against drafts, so for three months Trudeau stayed in the contaminated air of his brother's room, keeping himself awake at night with strong green tea. His brother died on December 23, 1865.

It was not known then that tuberculosis was contagious; Trudeau had no idea that he had caught it. He studied medicine at the College of Physicians and Surgeons in New York, got married, and set up a practice. Besides his regular practice, he had a class in diseases of the chest at the Demilt Dispensary with his friend Dr. Luis P. Walton.

Trudeau describes in his *Autobiography* how he discovered his illness.

I felt tired all the time, but thought it was the confinement of city life and paid but little attention to it. One afternoon I was at

the dispensary with Dr. Walton, and he insisted that I looked ill and took my temperature. To my astonishment it was 101 degrees. Walton advised me to go to Dr. Janeway and have my lungs examined, but I laughed at the idea. Of course there could be nothing the matter with my lungs. His insistence worried me, however, and next morning as I went by Dr. Janeway's office on West Fourteenth Street, the idea struck me that I would go in and have my lungs examined, so that the next time Walton berated me about my health I would be able to tell him that there was nothing the matter.

[Dr. Janeway] received me cordially and began the examination at once. When this was concluded he said nothing. So I ventured, "Well, Dr. Janeway, you can find nothing the matter?" He looked grave and said, "Yes, the upper two-thirds of the left lung is involved in an active tuberculous process."

I think I know something of the feelings of the man at the bar who is told he is to be hanged on a given date, for in those days pulmonary consumption was considered absolutely fatal.

For three years Trudeau stayed at Paul Smith's, and he later rented a house at Saranac big enough to hold his wife and their two children. There he stayed for more than forty years. And there, as time passed, he built the Adirondack Cottage Sanatorium and later the Saranac Laboratory for the Study of Tuberculosis.

Trudeau built his sanatorium because he wanted other patients to have the opportunity to rest in the quiet surroundings and fresh air, and he had discovered that the disease could be arrested in such a place. By 1883 he had selected a piece of land which he thought would be suitable, and was wondering how he could arrange for its purchase, when a group of Adirondack guides, who had learned his

plans, presented him with the deed. They had chipped in to buy the sixteen acres.

After that the first cottage to accommodate patients was built. It had one room and a tiny porch, and was furnished with a wood stove, an oil lamp, two cot beds, a washstand, two chairs, and a kerosene lamp.

Then other cottages were built on the hillside as more and more physicians sent tuberculous patients to try the rest, quiet, and pure air of that first American tuberculosis sanatorium. Doctors who had the disease themselves gave their services while they underwent treatment, and patrons who were willing to contribute funds for construction and upkeep were not hard to find. Years later a pleased Trudeau described the sanatorium.

> The mountains now look down on a different scene. The old boulders and rough pasture have disappeared, and macadamized roads, sloping grass lawns, flowerbeds, and ornamental shrubs have taken their place. The sanatorium has grown to be a picturesque little village. It comprises thirty-six buildings scattered over the entire hillside between the north and south gates, a distance of about three-quarters of a mile.

Trudeau watched the construction of the new buildings and the arrival of new patients with growing satisfaction. He remembered how hopeless he had felt when he himself had been driven over the rough road to Paul Smith's. It was good to be able to give encouragement to these other patients.

But though he saw them improve under his care at the sanatorium, and knew that for long periods their illness seemed to be arrested, he had to acknowledge that he was

not able to cure them. What was this illness? What caused it? Wasn't there some way of preventing it, as Jenner, for instance, was able to prevent smallpox, by vaccination? Wasn't there some way of curing it?

Sitting in the library of the house that he had built for his family at Saranac, Trudeau began to read of the researches of other men. He read of Pasteur's belief that all infections come from living germs. He read of Robert Koch.

Koch had demonstrated that the disease germ might be cultivated outside the human body. He had done some work on tuberculosis, and had written a book on it. American doctors were inclined to scoff at Koch's claims, but Trudeau wondered if there might perhaps be something in the German's ideas.

"But I can't read German, even if I could get hold of Koch's book," he said to his friend Mr. C. M. Lea one day. Mr. Lea was a publisher of medical books who had brought his wife to the sanatorium. He made no answer to Trudeau's complaint, and Trudeau continued to wonder what Koch had said in his book on tuberculosis.

At Christmas that year Lea appeared at Trudeau's door with a gift, and when the doctor opened it, there was Koch's book, *The Etiology of Tuberculosis*, translated into English.

Trudeau read the book with the greatest enthusiasm. It was a perfect specimen of clear and logical statement. Here Koch explained how he had obtained cultures from tuberculous patients; how he had made slides, staining them so that the tuberculosis germ could be distinguished under the microscope. He had even made drawings of the tubercular growths

on the lungs in various stages as they grew and changed. These were called "tubercles."

Trudeau was greatly stirred as he read of the great biologist's work. He himself would learn to make slides so that he could study the specimens he took from his patients. They would help him to make diagnoses in doubtful cases. He would learn to stain his slides so that he could distinguish the tubercles. He would find a way of growing the bacilli outside the human body. He would use these cultures for inoculating guinea pigs. Then he would experiment with some substance that would combat the tubercle. He would find a cure for the disease.

After long inquiry he discovered a professor of bacteriology who had worked in the laboratory of Robert Koch in Germany and, after packing a few things in his bag, went at once to New York to learn the rudiments of bacteriology.

He later wrote:

When I returned from New York, with my newly acquired knowledge as to how to detect the tubercle bacillus, I began at once to equip my small office . . . a room twelve by eight feet, having two small closets at one end—with such simple apparatus as I could devise and procure. In this little room I at first kept my microscopes and stains and made my numerous examinations of the secretions of patients, inoculated my guinea pigs, and began my attempts to make blood-serum tubes. My little homemade thermostat was placed in one of the small closets, and it was there that I first obtained a pure culture of the tubercle bacillus.

These quarters were so cramped, however, that I soon built a little addition off my office, and this became the laboratory in

which I worked until the house was destroyed in 1893 by fire originating from my thermostat. . . .

As I can remember today just how the Adirondack Cottage Sanatorium looked when it first began its humble career, so I can see equally clearly the room opening from my little office, which was really the beginning of the Saranac Laboratory for the Study of Tuberculosis. One side of this room was occupied by a long, high, stationary shelf-table set against the wall under three little half-windows, with shelves underneath the table for glassware, a dry and a steam sterilizer, an oil stove, etc. A little homemade thermostat, heated by a minute kerosene lamp, without any regulating apparatus, stood on a bracket shelf next to a sink for washing glassware. This sink was as primitive as the thermostat, as there was no running water in Saranac Lake in those days. At one end of the broad shelf stood a big pail with a dipper, and this supplied water (there was of course no hot water), and the waste from the sink was carried off by a leaden pipe which led to a big pail on the floor, this pail being emptied out-of-doors when danger of its overflow made this imperatively necessary. At the other window was a small table with my microscope on it, some bottles of stains, and slides in boxes. By the side of this stood a shelf of books on top of which was always Mr. Lea's precious translation of Koch's paper, to which the Saranac Laboratory has owed its existence.

When Trudeau's house was destroyed by fire the little laboratory was also destroyed, and the translation of Koch's book went with the rest. But Trudeau's friends, who knew what his work there meant, were quick with their help. Dr. William Osler, the Canadian physician, wrote:

Dear Trudeau,

I am sorry to hear of your misfortune, but take my word for it, there is nothing like a fire to make a man do the Phoenix trick.

And George Cooper, who had come as a patient to Saranac, and who took a lively interest in all that happened there, said to Trudeau, "I want you to begin to plan a good stone-and-steel laboratory—one that will never burn up."

In the new laboratory a small brass inscription was put up. It read:

Saranac Laboratory
for the Study of Tuberculosis

Erected A. D. 1894

Presented to

Edward L. Trudeau

by

George C. Cooper

There were no opening ceremonies, but when everything was ready, Trudeau and his assistant began to move his apparatus from a little shed into what he called "our beautiful new quarters."

That was the first laboratory building for the study of tuberculosis in America, and Trudeau set to work in it with high hopes. But though he worked for the better part of twenty years in the new laboratory, until he himself succumbed to tuberculosis, he never succeeded in finding the cure he sought.

Gradually, through his efforts and those of other men, the disease became better understood. Research now proved that there were several types of tubercle bacillus. Besides the type that occurred in human beings, there were those that

appeared in cattle, in birds, reptiles, and fish. The tuberculosis germs that were found in cattle proved so much like those in human beings that it was thought that they were the same, and that human tuberculosis could be developed from drinking milk of tubercular cows. Therefore, state and federal governments began to test the herds and destroy the tuberculous cattle. In this way many cases of tuberculosis were prevented.

Soon it appeared that the presence of tuberculosis could be detected by chest X rays, and great X-ray programs were begun. These showed that a large percentage of adults, especially in large cities, had tuberculosis, that the germs occurred not only in the chest but also in bones and other parts of the body. While they might become active at any time, the germs were especially dangerous during youth and middle age. And it was found, finally, that those who were well nourished and well rested were more likely to resist the germs. Trudeau had discovered that the disease could be checked by long periods of inactivity, but this often took as much as ten years. Now it was found that the lung itself could be rested by collapsing it through chest surgery, and the disease could often be arrested in one or two years.

While these facts about tuberculosis were being gradually collected, the great search for a cure for the disease went on.

Trudeau's little laboratory was succeeded by a whole host of other laboratories. There were laboratories for studying the disease and its treatment in universities and in large

pharmaceutical concerns. Funds for studying tuberculosis were provided by the great foundations. The National Tuberculosis Association raised huge sums for this purpose.

Before very long a tuberculin test was developed which, added to X-ray photographs, made early diagnosis possible.

Thousands of dollars were spent in studying new means of treatment. Streptomycin, a new drug, appeared to be most promising, but it was not really a cure.

For no cure for tuberculosis has been found. Yet studies that Trudeau and others have made show that with vigilance the number of cases can be kept down. Rest and adequate nourishment help the individual to combat the disease once it has started, and care can prevent its spread from one person to another.

The crowded country of India is a case in point. There poverty prevents most people from obtaining an adequate diet, and overcrowding makes healthful living impossible. There is a great shortage of doctors and nurses, so that those who are sick have little chance of help.

In India, therefore, tuberculosis spreads with terrible speed. There are two and a half million cases each year, and of those afflicted, five hundred thousand die.

With better nourishment, better housing, more doctors and nurses, this fearful situation could be prevented In Denmark, for instance, where the populace is well housed and fed, and there is adequate medical care, only about twelve people in each hundred thousand cases die.

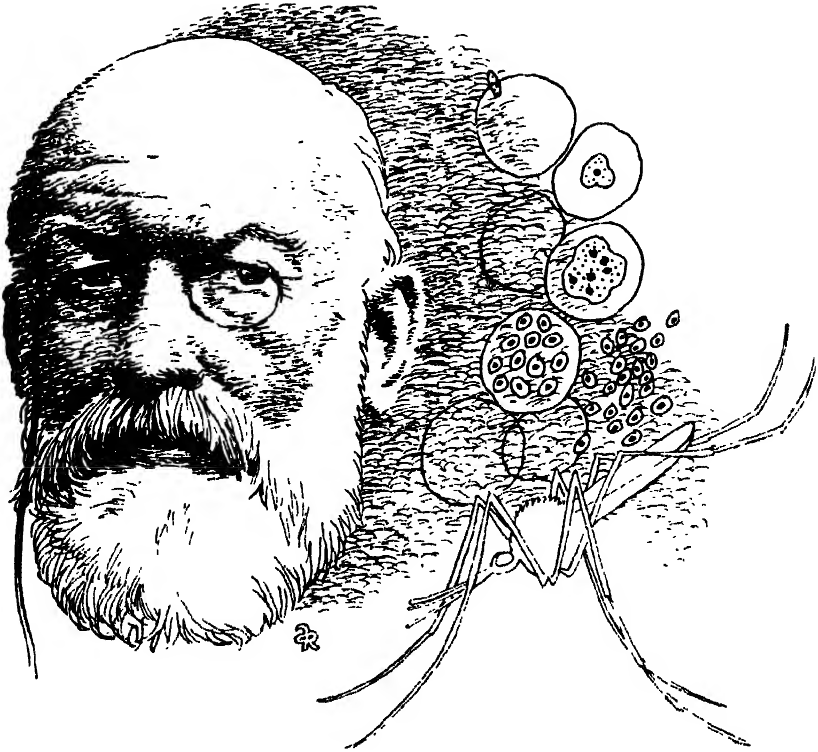
If further proof is needed that social conditions affect the tuberculosis rate, it may be found again in studying condi-

tions in the Second World War. In France during the German occupation there was very little coal during the winter, and very little food, and the curve for tuberculosis went up sharply. It also went up in Berlin when that city was blockaded after the war, and people were in want of food and fuel. Nothing could have stopped the ravages of tuberculosis caused by the war in these places—nothing except perhaps coal and bread and butter.

The control of tuberculosis, then, is not a matter that can be put in the hands of doctors alone. It needs the help of everyone to see that people are well fed and well housed.

Dr. E. Berthet of the World Health Organization, one of the specialized agencies of the United Nations, stated the matter clearly in two paragraphs when he said, "TB is certainly a social disease in relation to the standard of living of the population, and its eradication depends on the improvement of the human condition.

"The real prevention of TB does not consist only in systematic radiological examinations and construction of sanatoria, but also, and even chiefly, in providing human beings with healthy houses, sufficient diet, and decent standards of living."



XIX. THE MYSTERY OF MALARIA

MALARIA is as old as history. Egyptians shivered and burned with it in Imhotep's day, and Babylonians in the Tigris–Euphrates Valley suffered from its ravages. Hippocrates wrote of cases he had treated, and Alexander the Great probably died of it.

Through all the ages, no one knew how to prevent the fever, nor how to help those who suffered from it—not, at

least, until the Peruvian Indians in South America started to brew a medicine from what they called the "fever-bark tree." Even then the Europeans knew nothing of their remedy.

The fever-bark tree, or red-bark cinchona, has been said by naturalists to be the most beautiful tree in the world. It covers the slopes of Mount Chimborazo, that dormant volcano that towers so grandly above the green valleys of the Andes. The leaves of the fever-bark tree shine in the sun: they are bright green on the young trees and fiery red on the older ones. The whole mountainside where they grow looks like a bright woven blanket.

Other cinchona trees besides the red-bark are scattered through the Andean forests. Some of them have large leaves, some small ones; some have smooth leaves, some corrugated; and some have slender lance-shaped leaves. Their leaves are of red, brown, and green; the flowers are pink, lavender, and red.

The Indians knew that they could make medicine from the bark of all these trees. Indeed, there was no other way of combating malaria anywhere in the world—or not until 1930.

Before that time in Europe many ways of fighting malaria had been tried. When purging and bleeding failed, people tried witch-hunting and astrology. But one of these measures was as useless as another. They had decided that nothing could be done, when cargoes of the Indians' fever bark began arriving in the Spanish ports.

According to an old legend, the first European to discover the Indians' drug was a nameless soldier. Shaken by chills and burning with fever, he had been left in the forest to die,

when he succeeded in dragging himself to a pool of water, and drank. The water was bitter, but it quenched his thirst, and he slept. The next morning when he awakened he was well again, and he ran through the woods after his companions and told them of the bitter-tasting water he had drunk. They returned to examine the pool and saw a log of the red-bark cinchona lying in the water.

Perhaps because this tale of a common soldier appeared to have little glamour, another story of the cinchona bark was told and widely believed. In the city of Lima, Peru, the wife of Count Cinchón, the viceroy, fell desperately sick. The count could find no way to help her and was in utter despair when he received a letter from one of his governors telling him of an Indian medicine, the fever-bark. The countess agreed to try the Indian remedy, and "recovered sooner than you can say it."

An old record states:

When this was learned in the city, the people approached the Vicereine by intermediaries, not so much joyfully and congratulatorily but supplicatingly, begging her to deign to help them, and say if she would by what remedy she had at last so marvelously, so quickly recovered, so that they, who often suffered from precisely this fever could also provide for themselves.

The Countess at once agreed. She not only told them what the remedy was, but ordered a large quantity of it to be sent to her to relieve the suffering of the citizens—not only did she order this great remedy the bark to be brought, but she wished to dispense it to the many sick with her own hands. And the thing turned out so well that just as she herself had experienced the generous hands of God in that miraculous remedy, so all the needy who

took it marvelously recovered their health. And this bark was afterwards called the Countess Powder, which in Spanish is *los Polvos de la Condesa.*

A fine story, this, and it was believed for more than three hundred years. Then historians discovered that the wife of Count Cinchón had died before her husband was appointed viceroy of Peru, so she could not possibly have been cured by the Indian remedy. Nevertheless the Spaniards named the fever bark "cinchona," after the countess, and a considerable amount of the bark was brought to Spain.

The Jesuits, who had learned a great deal about medicinal plants from the Peruvian Indians, also brought cargoes of the fever bark to Spain and Italy and watched the quick recovery of the patients to whom they gave their medicine. Their ministrations were so successful that there was a great demand for the bark. The Jesuits were soon busy having the bark cut, packed, and loaded, to be sent across the ocean, and teaching the Indians how to cut the trees and plant "five new trees in the shape of a cross" for every one they cut down. People in Europe now were beginning to speak of the "Jesuits' bark."

With the coming of the religious wars to Europe, Protestants became suspicious of everything the Jesuits did, and doctors refused to use the Jesuits' bark. But a charlatan named Sir Robert Talbot mixed the drug with wine and herbs and gave it to Louis XIV. The French monarch recommended Talbot's services to the queen of Spain and to other eminent personages, because he himself had been cured. These grandees recovered from their fevers, and Sir Robert

Talbot was unable for long to keep his remedy secret. It was the old cinchona bark that had been brought from South America.

Now there was a struggle among the leading European nations to monopolize the supply of the bark by starting cinchona plantations, for careless cutting soon depleted the South American supply.

The competition became all the more keen, for in 1820 a way was found to extract an alkaloid of quinine from the cinchona bark. Quinine was more effective than the old tincture of crude bark had been.

Gradually, because the bark was scarce, the price of quinine rose. It became so high that thousands who suffered from malaria could not afford to take the only drug that would relieve it. If they could only find out what caused the sickness, doctors said, some better way to cope with it could be found.

In the year 1880 Major Charles Louis Alphonse Laveran was put in charge of the French military hospital at Constantine, in Algeria. The major was only thirty-five when he received this appointment, but he had had a good deal of medical experience. He had served in the ambulance division at the battles of Gravelotte and Saint-Privot in the Franco-Prussian War. He had been through the siege of Metz and had seen that city capitulate.

But experience with sick and wounded is not of much use to me at Constantine, Major Laveran thought. Fever is the only problem—a hard problem.

Daily he watched the pallor spread across the sunburned

faces of the men under his care. He saw them shiver with violent chills that made their arms and legs shake and their teeth chatter uncontrollably. He saw the fever start, mount higher and higher, and then recede. And after a pause of either forty-eight or seventy-two hours he saw the whole cycle repeat itself, while the men grew gradually weaker and more listless and numbers of them died.

If I could only find out what causes it, Major Laveran thought. Could it be "bad air," he wondered, as some had claimed? The Italians thought so. The name malaria, he knew, had come from Italy—*mala* means "bad," and *aria*, "air." But the idea of bad air was unsatisfactory to Major Laveran. What made the "bad air" in some places and not in others? Were there gases that rose from the ground, carrying the sickness with them? "Not likely," Major Laveran said to himself.

In his miltary hospital at Constantine he thought more and more about the causes of malaria. Only very recently Louis Pasteur had announced his theory of microbes. Could this sickness be caused by a microbe? Many French doctors were skeptical about Pasteur's theory, but there might be something in it.

Laveran sent to France for a good microscope and began examining specimens of blood. He did not find bacteria. The blood of his malarial patients looked like other blood under his lens. The red cells and white cells floated in a yellowish fluid. But when he concentrated his attention on the white blood cells he saw what many others before his time had seen. The white blood cells of the malarial patients were

peppered with little dark specks. No one knew what they were or why they were there.

Laveran began to shift his attention to the red blood cells. Here he saw a curious thing. Within the red blood cells of the malaria victims there was a kind of bluish-white sphere, like a tiny soap bubble. On the surface of the soap bubble he saw a red speck with black dots clustered round it. As he examined the sphere with its dots Major Laveran saw it move with a kind of undulating motion.

Fascinated, he held his eye down close to the microscope and watched. The bluish sphere began to enlarge; the red dot broke in two, and then in four, and then in eight. Finally the sphere grew so large that it burst. The red and black dots were floating free in the yellow fluid.

Now the red specks themselves began to change. Some of them became egg-shaped, others curved like crescents, while still others thrust out long filaments that waved about like the tentacles of an octopus in the yellowish fluid. But the red cell in which they had grown was completely destroyed.

Then Laveran noticed how the white cells swallowed up the fragments in the yellow fluid, and so became the polka-dotted white cells of the malarial patients.

He lifted his eye from his microscope at last and pushed his chair back from the table. "It is animal life multiplying there," he said. "Some of those cells are parasites."

He promptly wrote a paper announcing his discovery to the French Academy of Science in Paris. The final paragraph read, "The accidents of malarial fevers are caused by the introduction in the blood of parasitic elements which take

the different shapes described; it is because it kills these parasites that quinine puts a stop to the accidents of malarial fevers."

Major Laveran had made one of the greatest discoveries in medical history. Ten years after his discovery, reports came from Russia, the United States, and India: scientists in those countries had found the same parasites in the blood of malarial patients. Soon the reports were coming from all around the world. Everywhere the findings corroborated what Laveran had found.

But the work on malaria was not yet complete. For if there were parasites that multiplied in the blood of malaria patients, destroying the red corpuscles, how did they get there? Dr. William Osler of Johns Hopkins University in Baltimore summed up the difficulty when he wrote:

> We do not know how the parasite enters, or how or in what form it leaves the body; how or where it is propagated, under what outside conditions it develops, whether free or in some aquatic plant or animal.

Dr. Osler wrote that passage in 1892, but the mystery of the parasite was not to last long. For scientists in many countries were prying into the secret existence of the malarial parasite.

Major Laveran himself had believed that the parasite might be carried by mosquitoes, but he had not proved it.

Just as in a mystery novel, where various clues seem to point toward the murderer, but the crime is not solved until the end of the story, so the idea was abroad that mosquitoes

might be the carriers; but no one had actually solved the mystery.

Then Sir Ronald Ross, a surgeon in the British Indian Army, found that mosquitoes could transmit malaria from one bird to another. The mosquito bit a sick bird, sucking up blood that contained the parasite, then bit a healthy bird and injected the parasite into it by means of the saliva.

It seemed to Ross certain that the malarial parasite was spread among humans in the same way. But he could never prove it, for he had been working with the wrong kind of mosquito—the kind that does not feed itself on human blood.

In the marshy lands of Italy there are mosquitoes of almost every kind. It is therefore not surprising that the final step toward hunting down the carrier of the malarial parasite was taken by Italian scientists. They proved that it is the female anopheles mosquito that spreads the malarial parasite.

When it was learned that this mosquito was the enemy, the mystery of malaria at length was solved. Now it became known that the victim shivers with chill the instant the micro-organisms are freed from the red blood cells in which they have multiplied. When the red blood cells break up, the chill is changed to fever and the patient is soaked with perspiration. Anemia and weakness follow the destruction of the red blood cells. Then the whole cycle begins again.

The female of the anopheles mosquito is the only one responsible for the trouble. It may be distinguished from the male by its smooth antennae. The male mosquito of this

species has antennae covered with silky hairs. It does not suck blood but feeds on vegetable juices.

After the female anopheles has had its fill of blood it sits quiet and unnoticed on some wall or ceiling. It stays there from ten to fifteen days, while the parasites it has drawn in multiply. After that they move up from the mosquito's stomach and are passed out with the saliva as the mosquito pricks the skin of a human being.

With the solution of the mystery of malaria, hope has come to people around the world. It is hard to estimate the exact number of people suffering with acute cases of this disease—no one knows how many there may be in the Chinese Republic or Russia, for example. But it is thought that there are not less than three hundred and fifty million acute cases, and that about three million people die of malaria every year.

These figures do not give a picture of the millions more who are half-sick with recurring attacks of the disease which the Greeks called the "horror," nor of the misery and poverty and despair that result when men and women feel too ill to work.

However, those who have malaria now no longer need to depend on the depleted forests of the fever-bark tree for a remedy. Atabrine, a synthetic drug, was made by a great German chemical firm in 1930, and in laboratories in the United States three additional drugs were prepared during the Second World War, when American troops in the tropics were suffering severely from malaria. These drugs all give relief to malarial patients.

But it is better to prevent a disease than to cure it, and a great campaign has been organized to do away with the anopheles mosquito.

Eighty different nations have now joined together in the World Health Organization. One of their ambitions is to eradicate malaria completely. Spray guns are the weapons in the great campaign; DDT the material of war.

DDT is an abbreviated form of "dichloro-diphenyl-trichloroethane." After this substance has been sprayed, a thin film is left on walls and ceilings, where malarial mosquitoes rest. The chemical is deadly to the mosquito; it has only to touch the deposit left by the spray and the poison takes effect. The residual spray will last on the walls for a number of months.

In South and Central America, in Africa and Indonesia, in the Philippines and India, workers with spray guns have been entering houses to spray DDT on walls, ceilings, and into the dark corners where the anopheles mosquito may be hiding. At first the people in many places were afraid, not knowing what dangers this strange procedure might bring. Then the workers of the World Health Organization stopped to make friends with them and explain what they were doing, and now they are generally welcomed everywhere.

So with great enthusiasm and unfailing vigor the sprayers did their work and painted a symbol on each house to show that it had been sprayed. Patiently they hunted out their enemy.

Even while this work was going forward, however, it was discovered that the mosquitoes were beginning to build up

a resistance to DDT. Unless the spraying was done quickly, the chemical might not destroy them after all; and if this happened, precious time would be lost, while chemists worked to develop some other spray. Now, therefore, the men pumped faster and faster.

By 1956 it was estimated that as a result of energetic work more than two hundred and thirty million people had been protected from malaria. But millions still wait for help. It will be seven or eight years, members of the World Health Organization say, before they are able to beat back the old horror of malaria.

XX. FOUR AGAINST THE YELLOW JACK

YELLOW fever, which is sometimes called yellow jack, is also carried by mosquitoes, though not the same kind of mosquitoes that spread malaria. Many people suffered and many lives were lost before the cause of yellow fever was discovered. But afterward it was not difficult to conquer the disease.

There were four outstanding men who worked against the scourge of yellow fever: Carlos Finlay, the gentle Cuban doctor whom people said was "touched"; Walter Reed, of the United States Army Medical Corps; Hideyo Noguchi, the great Japanese bacteriologist; and Adrian Stokes of the Rockefeller Institute. Both these last were killed by the yellow jack before they had completed their work.

Of the four Carlos Finlay did most—and his work was least recognized.

Finlay was born in Cuba, though there was French and Scotch blood in his veins as well as Cuban. He had studied medicine in France and at Jefferson Medical College in Philadelphia, where he was a friend of the well-loved physician, Silas Weir Mitchell. In Havana, when he came back to practice medicine, people were accustomed to see him walking

about the streets, immaculately dressed in white. His eyes were kindly behind gold-rimmed spectacles, and he liked to laugh.

There were many things that Carlos Finlay enjoyed. He liked good conversation, Havana cigars, fine wine, a game of chess. He was devoted to his three sons and to his wife. Most of all, perhaps, he loved his work: those patients that he tried to help and often forgot to charge for his services; and the research that he carried on in a small, poor laboratory, which was the best that he could afford.

Carlos Finlay believed that the worst afflictions the people of his country suffered were the recurring epidemics of yellow fever. It killed on the average fifty per cent of all the people who caught it. He wanted to find out what caused it and how it could it be controlled. Yellow fever was one of the most baffling mysteries in tropical medicine.

Finlay was a student of history as well as of medicine, and he read the records of the old epidemics that had occurred back in the fifteenth and sixteenth centuries, when the Spaniards had first come to the New World. Later he obtained translations of the old Mayan writings that seemed to him to prove that there had been three epidemics of yellow fever in the Yucatán Peninsula before the Spaniards came. As he read, he formed the conviction that yellow fever was indigenous to the Americas, that it had been carried from the Western hemisphere in the old sailing ships until it was to be found in tropical countries all round the world. But what was it that was carried? How was it carried?

Laveran had made his announcement that malaria was

transmitted by mosquitoes in 1880, and the following year Carlos Finlay, after much patient study and much thought, was ready to say that mosquitoes carried the yellow-fever germ too. He wrote:

> In order to inoculate yellow fever it would be necessary to pick out the inoculable material from within the blood vessels and carry it likewise into the interior of a blood vessel of the person who was to be inoculated. All of which the mosquito satisfied most admirably through its bite, in a manner which it would be almost impossible for us to imitate, with the comparatively coarse instruments which the most skillful worker could produce.

In February 1881 Carlos Finlay attended a meeting of the International Sanitary Conference in Washington, D.C., and read a paper announcing the theory that yellow fever was transmitted by mosquitoes.

Then in August 1881 Finlay was ready to tell what kind of mosquito carried the disease. It was the stegomyia mosquito, which is called *aedes aegypti.*

Carlos Finlay must have neglected his practice somewhat between February and August that year, so busy was he studying mosquitoes. He caught them in test tubes, and he learned about their breeding habits and their life cycles. He dissected them and wrote long reports on what he found with his microscope. He distinguished a number of species, and found that some mosquitoes could live for as much as seventy days or even longer.

It was plain to him that the fever-carrying mosquito would breed wherever conditions of moisture and temperature were

suitable, and that the way to stamp out the disease was to do away with these breeding places.

People now began to call him the "mosquito doctor," and he knew that some of them said he was "touched." That did not matter to him. He went on with his patient work for twenty years. He had one physician friend in Havana who believed in what he was doing, and the members of the Cuban order of Jesuits were sympathetic to him also. Otherwise there was no medical man in either North or South America, or anywhere else, who gave him any encouragement. Time and time again he presented his ideas in medical journals and at medical meetings, but no attention was paid to them.

Though it was a mystery to other people how yellow fever was carried, it was plain that the disease was becoming increasingly prevalent. Eighteen-ninety-eight was the year of the Spanish-American War, and many more soldiers died of yellow fever than from enemy bullets. One-third of the commissioned officers on General Leonard Wood's staff succumbed to it.

If North Americans were to remain in Cuba after the war was over (as they had every intention of doing), something must be done about yellow fever. For this reason the United States government sent a commission to Cuba in 1900 with orders to "give special attention to questions relating to cause and prevention of yellow fever." Major Walter Reed headed the commission. Its other members were Dr. James Carroll, Dr. Jesse Lazear, and Aristides Agramonte, a handsome young Cuban.

As soon as their ship landed in Cuba the commission set to work. It tried to discover what had caused the disease by performing autopsies on eighteen men who had died of yellow fever. But they could not find the microbe. It was rather difficult for them to know exactly what to do next.

Walter Reed had heard of Carlos Finlay, and rather reluctantly he decided to go to see him. Finlay greeted Reed with warm generosity. He took him to his laboratory and showed him his mosquito collection.

"This is a specimen of the stegomyia mosquito," he said, "this one with the silvery stripe on its thorax and white stripes around the leg joints."

Yes, he had studied its habits. It liked to breed in clean standing water, was more likely to be found in towns than in the country. The female laid its eggs at night, often twenty-five to seventy to "a raft." The eggs were jet-black and unusually tough. You could hardly destroy them, even by freezing. He had stored them for as much as three months in a dry box and still they would hatch.

When Walter Reed finally left Dr. Finlay, he carried with him some of the little black eggs.

"You might like to experiment with them yourself," his host said. "If there is anything at all that I can do to help you . . ."

Walter Reed thanked him and went back to his headquarters

It appeared that there might be something to Finlay's ideas. But what had the old doctor done to prove them? There ought to be many controlled experiments. There ought

to be *proof* whether yellow fever was actually transmitted by mosquitoes or not. How could such proofs be made? Usually doctors used animals for experiments, but there did not appear to be any animals that were susceptible to yellow fever. To ask a man to allow a mosquito to bite him in order to see whether the insect carried the germ then seemed unthinkable.

"That is the only thing that we *can* do," said Walter Reed.

The members of the commission felt it right that they should themselves be the first subjects of the experiment, and they therefore allowed themselves to be bitten by mosquitoes raised from the eggs that Dr. Carlos Finlay had given Walter Reed. Reed himself had been called back to Washington before the test was begun, but the others carried on the work according to his directions.

First, they took the mosquitoes to the yellow-fever ward and allowed them to bite the patients several times. Then they caught them in their test tubes, and allowed themselves to be bitten. Dr. James Carroll came down with a severe case of yellow fever six days after he had been bitten, but he recovered. Aristides Agramonte did not get the fever, nor did Dr. Jesse Lazear. However, Dr. Lazear was bitten accidentally several days later. He saw the mosquito settle on his hand but thought it was of another species. The fever that developed was fatal.

It appeared that there might be something in Dr. Finlay's contention, but Walter Reed, who had returned now from Washington, felt that further proof was needed. He called for volunteers among the men in the army, explaining to

them possible dangers and offering two hundred and fifty dollars to anyone who would volunteer to be bitten by one of the mosquitoes with the silvery stripe on its thorax. The men were slow in coming forward, but finally two of them volunteered. They were Private John R. Kissinger of the Hospital Corps, and John J. Moran, a headquarters clerk.

"The one condition on which we volunteer, sir," they said, "is that we get no compensation for it." Private Kissinger explained that they had volunteered "solely in the interest of humanity and the cause of science."

Walter Reed was impressed. He drew himself up and touched his cap. "Gentlemen, I salute you," he said.

So the two volunteers were bitten by the fever-carrying mosquito. Moran did not get the disease, but Private Kissinger came down with it five days later. Fortunately he recovered. After that five Spaniards who had recently arrived in Cuba offered to be bitten for a money compensation. Four of them contracted yellow fever.

Walter Reed was greatly pleased with the success of his experiments. "Rejoice with me, sweetheart," he wrote his wife, and added that, "Except for the diphtheria antitoxin and the discovery of the bacillus of tuberculosis, it will be regarded as the most important piece of work, scientifically, during the nineteenth century.

"It was Finlay's theory," he went on, "and he deserves great credit for having suggested it, but as he did nothing to prove it, it was rejected by all. . . . Now we have put it beyond cavil."

In his exuberance Walter Reed was not content to stop

there. He wanted to prove that yellow fever could not be transmitted in any other way except by the mosquito. Therefore he had some of his men sleep for twenty nights in a small, carefully screened hut, in which he had put clothing, bed linen, and blankets that had been soiled by yellow-fever patients. None of the men contracted yellow fever from contact with these things. To make his proof doubly certain he tried having these same men bitten by the fever-carrying mosquitoes. When they contracted the disease, he felt sure that his theory had been right.

Walter Reed received great acclaim for his work. The officers of the United States Army were filled with enthusiasm. All they needed to do to abolish mosquitoes, they thought, was to drain the swamps, clean up the stagnant puddles, pour a thin coating of oil on reservoirs and ponds, and so destroy the grubs of the fever-carrying insects. They would abolish the mosquitoes by making it impossible for them to breed. Then the army could establish itself anywhere in the tropics. The technique was quite different from that used against the carriers of malaria.

It did not take them long to drain the swamps and pour oil on the stagnant water in Cuba. Dr. Carlos Finlay had already made a good start with the work there. Down on the Isthmus of Panama the United States had almost been prevented from building the Panama Canal because so many of the workmen had come down with yellow fever But General William C. Gorgas established a systematic mosquito-control program and Panama achieved a record as the healthiest country in the world at that time.

The drainage of puddles and swamps was continued long after the canal had been built, but later the use of oil for destroying mosquito larvae was given up; small fish were placed in tanks and ponds to destroy the "wrigglers," as the men called the mosquito larvae.

But it turned out that there was more to controlling yellow fever than simply killing mosquitoes. The disease kept turning up in different parts of the world. The last epidemic in the United States was in Louisiana in 1905, but no one knew when it might appear again. It cropped out in Africa and Asia and on the islands of the Pacific at about the same time. In Brazil, between 1908 and 1938, there was a seventeen-hundred-per-cent increase in yellow-fever deaths.

There were still so many unanswered questions. Was it true, as Walter Reed supposed, that all animals were immune to it? Was it possible to isolate the virus? Could an effective preventive inoculation be worked out?

Those questions were so difficult that their solution demanded all the knowledge and skill of modern science. And the work on them was so dangerous that only the hardiest dared to undertake it.

But men of scientific skill and hardihood were not lacking. A number of them sought to study yellow fever under the aegis of the Rockefeller Institute.

One of these was Adrian Stokes, a physician and bacteriologist, whose M.D. degree had been awarded him by the University of Dublin. Dr. Stokes had been called by the Rockefeller Institute to go to West Africa to work on yellow fever. He set off, expecting to return in a year. Before the

year ended he had contracted the disease himself, and died of it in a few days.

Before he died, however, he made a very great discovery. He had found out that certain species of monkey are susceptible to the disease. This was extremely important, for it made experimentation possible without endangering human lives. By animal experimentation it was proved that mosquitoes, as Walter Reed had said, must first bite an animal sick with the fever before they could pass it on.

One of Adrian Stokes's friends, who worked with him in West Africa, was the Japanese physician and bacteriologist, Hideyo Noguchi. Noguchi, whom some have called the greatest of bacteriologists, was also sent to West Africa by the Rockefeller Institute. After a short study he determined that yellow fever was caused by a virus so minute that it could pass through a filter. This virus had never been isolated, but nevertheless Noguchi developed a serum which could be used to vaccinate against it.

He believed that he was just about to isolate the virus that caused the disease when he too was stricken and died within a few days.

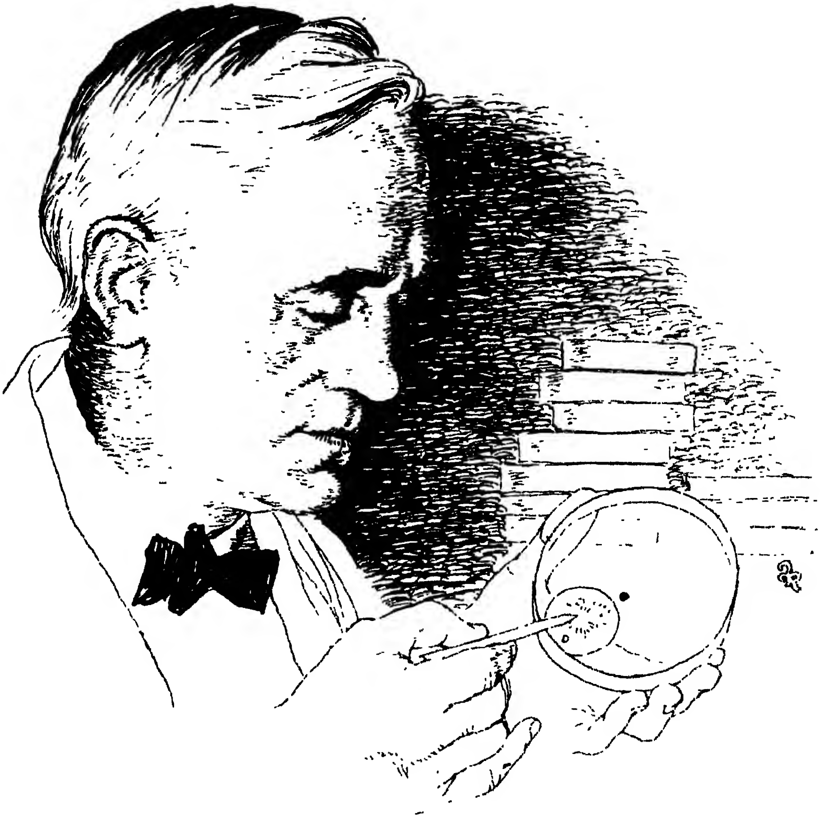
Other researchers, and especially those at the Rockefeller Institute, pushed the work of Stokes and Noguchi forward, however. Soon the Institute was ready to report that there were as many as fourteen types of mosquitoes that carried the germs, and that many jungle animals were infected by the virus. And now they were prepared to state that yellow fever was primarily a disease of jungle animals; that jungle yellow fever was carried from one animal to another by mos-

quitoes; that the virus continued to circulate in the blood of susceptible animals for three or four days and did not subsequently reappear. Mosquitoes, however, that had once been infected harbored the virus for the rest of their lives, which might be as long as several months.

Since it was impossible to do away with all the infected jungle animals or all the virus-carrying mosquitoes, the Rockefeller Institute recommended that the best way to fight the disease was through inoculation. Building on the work which Noguchi had started, they developed an effective serum, "Virus 17-D."

Because of the danger of carrying persons with incipient cases from one place to another, inoculation of all passengers on ships and airplanes traveling from one continent to another was required. The native population of such places as Brazil and West Africa were persuaded to allow themselves to be pricked with the doctor's needle. In the fourteen years between 1939 and 1953 forty-four million people were inoculated against yellow fever, and were therefore made safe from the disease even if they were bitten by stray mosquitoes.

The great work that such men as Carlos Finlay, Walter Reed, Hideyo Noguchi, and Adrian Stokes had started had come to its fruition.



XXI. A FLECK OF MOLD

CAPTAIN Alexander Fleming, of England's Royal Army Medical Corps, stood at the door of the army hospital in Boulogne, watching the line of stretchers that was bringing the wounded men in from the fighting area. It was 1914. The German guns were snuffing out lives by the thousands.

The stream of men that Captain Fleming observed on their stretchers had wounds that were infected; at least half of these soldiers would not leave the hospital alive.

It is sad to see so many die, young Fleming thought.

He entered the ward and began to work on the first patient—a young soldier with a badly infected wound on his shoulder.

Most of the men at the Boulogne hospital were in serious condition. They had been treated at the first-aid stations, but often it was several days before anything further could be done for them, and the wounds flared up until the soldiers were struggling with blood poisoning, pneumonia, or some other type of bacterial infection. By the time they reached Dr. Fleming there was need of fighting the infections with some effective antiseptic agent. And this was the difficulty: Dr. Fleming had no such agent.

Diluted carbolic acid had served Lister well in his surgical work—but it was too strong to use in the massive doses that Fleming needed now. If he used enough of it to combat the microbes of widespread infection, he would destroy delicate tissues, and, worse still, he would destroy the white blood corpuscles, or leucocytes—without which natural resistance was broken down—leaving the way open for the attack of a whole new set of microbes. What was the sense of destroying one set of microbes only to make way for another? Fleming wondered as he watched local infections spread into septicemia, or saw his patients develop pneumonia which he could not often combat.

There must be some way of dealing with these infections,

Fleming thought. He was himself to find that way, although the world was slow to recognize his discovery.

The First World War was over at last. After four years' service Fleming resigned his commission, returned to England, married, and began to teach bacteriology at St. Mary's Hospital in London, where he himself had studied. In the laboratory at St. Mary's he spent many hours searching for the microbe-destroyer that he had needed so much in the army hospital during the war.

One day in 1928 he was working in the laboratory, as usual. A set of culture plates on which he was growing various kinds of bacteria lay on his table. The window was open behind him. He did not notice when a fleck of mold blew in. It settled on one of the culture plates; and there he saw it through his microscope.

He was annoyed at first. It would contaminate the plate and spoil the culture. He picked up the plate and was about to throw it away, when something stopped him. He examined the mold that had settled among the bacteria curiously.

"I was sufficiently interested to pursue the subject," he wrote in his notebook afterward. "The appearance of the culture plate was such that I thought it ought not to be neglected."

Now as he watched the tiny fleck through his microscope, his trained eye observed a strange thing. The mold was being surrounded by a halo of watery fluid. The clear little circle grew as he watched it.

Something in the mold is destroying the microbes, he thought. The bacteria are disappearing.

He wanted more of this mysterious mold that had floated in at his window. Carefully, with a little loop of platinum wire, he fished up a speck of it and put it into a special solution where he knew it would grow. And it grew quickly. At first it was fuzzy white; then it turned green, spreading fronds that matted together in a thick mass.

Fleming knew something about molds. This one with its branching fronds belonged to the *penicillium* family—the one that gave blue veins to Roquefort cheese, the one that destroyed apples in winter storage, the one that spoiled oranges. This special mold, however, was one that was new to him. What might it be? he wondered.

He called his two laboratory assistants and showed it to them. If this mold, as he suspected, was secreting some juice that could destroy microbes, might the juice perhaps be extracted from it and used to fight other bacteria?

The three men began at once to grow more of the mold, and to drop the liquid in which it was grown on plates covered with microbes. As they watched, the microbes disappeared, dying apparently by the millions.

They tried diluting the liquid, putting one part of it into one hundred parts of plain water. When they dropped this new solution on the culture plate it was equally effective. The same was true when they diluted it with two hundred parts of water, and with three hundred parts of water. Even when they made a solution of eight hundred parts of water, the microbes died.

Fleming wrote in his notebook in his neat, rather cramped hand, "It has been demonstrated that a species of Penicillium

produces in culture a very powerful anti-bacterial substance."

Eagerly now Fleming and his two assistants prepared more and more little dishes containing liquid in which they grew various kinds of bacteria. The liquid had no effect on the germs of typhoid fever, or of dysentery—it apparently would put up no fight with the bacteria of the intestinal tract. But when they tried it on the germs that caused blood poisoning, septic sore throat, some types of pneumonia, and other infections—then, every time, the halo of clear fluid surrounded the mold and the bacteria disappeared.

"A powerful antiseptic," Fleming had called it. But was it too powerful? If it was applied to a wound would it destroy also the leucocytes in the blood, and so do more harm than good? He took a little human blood serum, added the mold to it, and watched. The minutes and the hours passed. Examination of the blood showed that its composition had not been changed.

Now he was ready to try the solution on mice and rabbits. These animals paid little heed to the gentle antiseptic that he injected into them. The rabbits went on eating a cabbage leaf; the mice scampered about their cages.

He wrote in his notebook, "It is a more powerful inhibitory agent than carbolic acid, and it can be applied to an infected surface undiluted, as it is non-irritating and non-toxic."

Fleming decided to call the new antiseptic "penicillin."

In June 1929 he wrote a paper announcing the discovery of penicillin for the *British Journal of Experimental Pathology*. No one appeared to be interested. Even Fleming himself

realized that he could make only tiny amounts of the new antiseptic in his laboratory flasks, whereas large quantities would be needed to treat a single patient. He had made a discovery, but it appeared that it would do no one much good.

While Fleming was working on his penicillin a great many experiments were going on. The great Paul Ehrlich was searching for a cure for syphilis, and he had experimented methodically with six hundred and five compounds of arsenic before he succeeded in finding the six hundred and sixth compound, which he called salvarsan—but salvarsan did not always work. The body seemed to build up an immunity against it if large amounts of "606" were used. It seemed to less patient men fruitless to try to find cures by such pains-taking labor, but still, a great many were doing it.

In 1935, in Germany, the I. G. Farben Industries, under Dr. Gerhard Domagk, tried juggling the atoms that composed the molecules of various dyes, and created the sulpha drugs that were later perfected in France. These drugs could be used in pneumonia and in septicemia and other infections, and there was great enthusiasm over them. But soon it was found that they were not always effective—and they were so toxic that often it was dangerous to administer them at all.

So the old question that Fleming had asked in the First World War was still unanswered. The gentle yet powerful antiseptic was still not available. And Fleming's paper on penicillin lay forgotten on the library shelves for nearly ten years.

At Oxford, England, in 1939 new efforts to find a satisfactory antiseptic were being made. Dr. Howard Walter Florey, an Australian physician, with a group of assistants, was again seeking to discover some agent to use against infections. He had received generous grants from the Rockefeller Institute, the Medical Research Council, and the Nuffield Trust. Expense was no consideration for him. He was intelligent, well trained, and had able assistants. But try as he would, he could make no headway.

Then one day he happened to remember Fleming's paper on penicillin, which he had read long before. He went at once to the medical library and took it from the shelf. Here was the thing he had been looking for. He would get some of the mold, and try new ways of growing it. He would make it in large amounts, and test the effect of it on human patients.

Fleming had kept some of the strain of the original mold in his laboratory at St. Mary's ever since the time of his earlier experiments, and he was glad to let Florey have it.

Soon the shelves in Florey's laboratory were lined with hundreds of flasks, all growing green mold, and his assistants were experimenting with new ways of extracting penicillin from the broth in which the mold grew. In 1941, after many months of work, they had extracted exactly a teaspoonful of brown powder—the precious penicillin for which they had worked so hard. They believed that this would be enough, in solution, to treat one case of general infection.

There was a young policeman at St. Mary's at that time with a severe case of blood poisoning. The doctors had tried

to treat him with sulpha drugs—unsuccessfully. They knew of no other measures they could take and believed that he could not live more than a few days. Under the circumstances, they felt justified in trying penicillin.

In those early days the method of administering penicillin was to let it drip slowly by injection into a vein. Anxiously Dr. Florey opened the patient's vein and set the apparatus in place. Slowly the penicillin began to drip.

It was not long before those watching saw a change in the policeman. His temperature lowered, his pulse rate approached normal, the signs of blood poisoning abated. Hour after hour the penicillin solution dripped into the vein. And then, as they watched, their anxiety mounted: the penicillin they had worked so long to make was exhausted! They saw the last drop of the precious solution slip down the tube. Then they saw the signs of blood poisoning return, and ultimately they saw the patient die.

But Dr. Florey knew now what penicillin could do. He was sure of the great power that had come into his hands. The signs of blood poisoning had abated under the penicillin attack.

Patiently he and his assistants went to work to make more of the powder. Finally they succeeded in making enough of the substance to administer it to six patients. Two of these patients died; four recovered. The physicians were sure that if they could make it in larger amounts they could get the results they wanted. So they tried to get commercial chemical plants to manufacture penicillin on a larger scale.

But England was in a life-and-death struggle with Ger-

many in 1941: all her resources were being put into making munitions and equipping her armies. There was no company that could be spared for manufacturing a new and little-tried drug.

Late in the summer of 1941, with funds supplied by the Rockefeller Institute, Florey and one of his assistants crossed the ocean to America. American research men were more than receptive to Florey's call for help. What was needed, they agreed, was some way of producing penicillin in large amounts. They tried to improve the strain of mold, to find some medium in which it would grow faster. And when these efforts still proved too slow, they enlisted the help of the United States government. In 1943 the War Production Board released certain chemical companies to work on penicillin production and allocated materials for necessary equipment for manufacturing, since this country too was at war. Penicillin was needed for the soldiers, and the government wanted to do all it could to produce it.

Penicillin now was made not in laboratory flasks but in towering tanks. Inside the tanks the mold was grown on wooden chips impregnated with a liquor made from corn. The tanks were as big as freight cars, and in them the mold fermented for several days. The liquid in which the mold was grown was finally drawn off, and the penicillin was separated from the liquid by a chemical process.

This was American mass production. The penicillin which had been painstakingly made by the teaspoonful was being produced in quantities large enough to treat the infected wounds of an army. Soon casualties in the armed forces were

dropping, and men who would have died in an earlier war were being sent into action after a few days' treatment. Fleming's penicillin was playing its part in winning the war.

By 1944 so much penicillin was being turned out that there was enough to treat the civilian population as well as the army.

The discovery of the new drug appeared to many to be indeed a miracle, but there were still bacterial infections that penicillin could not combat. Administering the drug did no good in cases of tuberculosis or of undulant fever, of typhus or of the virus pneumonias. And there were a number of other sicknesses caused by bacteria for which it was of no use.

Research scientists, seeking remedies for illnesses such as these, remembered that penicillin had been developed from a mold. It therefore seemed probable to them that other drugs could be made from other molds. So the search for new antibiotics began and was soon extraordinarily successful.

In 1944 Selman Waksman, a Russian who had immigrated to America and was working at the New Jersey State Agricultural Experiment Station in New Brunswick, developed streptomycin through studying the bacteria of highly manured soil. The new drug appeared to destroy a great variety of organisms that were resistant to penicillin, among them the one that causes tuberculosis.

Three years after Waksman had made his discovery, John Ehrlich succeeded in isolating a strain of mold which he called "chloromycin." He made this from samples of soil collected near Caracas, Venezuela, and found that it could be

used successfully in cases of typhus fever, Rocky Mountain spotted fever, and typhoid fever.

Only a year after that, in 1948, a scientist named Benjamin M. Duggar, who was professor emeritus at the University of Wisconsin, developed aureomycin, which could be used in combating virus pneumonia and chronic infections of the urinary tract.

So, one by one, the so-called "mycins" are still being developed, and men have learned that bacteria may be fought with other bacteria even when they are so minute that they cannot be seen under high-powered microscopes. The Salk vaccine for the treatment of poliomyelitis is a recent example. This is one of the latest steps in the long history of medicine.

Today physicians, using the knowledge that has been accumulated through the generations before them, continue their work. Their medicines now are antibiotics and other modern drugs. Their stethoscopes are neat efficient instruments of metal and rubber which they keep, not inside their hats, but in little leather cases. They have all sorts of scientific devices to help them in diagnosis.

But even in the twentieth century, after the passage of so many years, most men of medicine are still the followers of Hippocrates, who said, "Into whatever houses I enter, I will go into them for the benefit of the sick." And: "Where there is love of men, there is love for the healing art."

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